International Marine Engineering

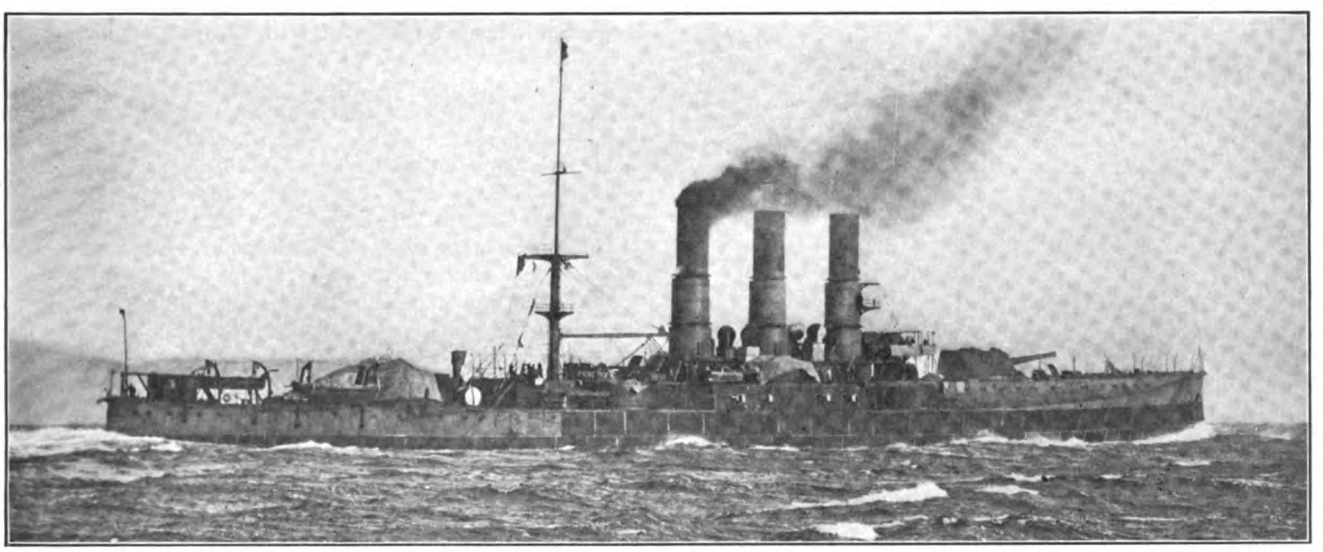
NOVEMBER, 1909.

THE ITALIAN BATTLESHIP ROMA.

BY DAGNINO ATTILIO.

Two first-class battleships have recently been added to the Italian navy, both built on the same general lines, but differing in certain particulars. They are the *Napoli,* built in the navy yard at Castellamare, di Stabia, and the *Roma,* built in the navy yard at Spezia. The differences are more or less minor in character, and the description will be confined to the *Roma.*

As mentioned in a previous issue, the ship has the following dimensions: Length between perpendiculars, 435 feet; length over all, 474½ feet; breadth, 73½ feet; draft, 25 feet 9 inches; displacement, 12,625 tons.



THE ROMA AT SEA. THE UPPER PART OF THE FUNNELS WILL EVENTUALLY BE CUT.

The propelling machinery of the *Roma* was built by Messrs. Ansaldo, Armstrong & Co., at their Sampierdareno works.

The two main engines are four-cylinder, triple-expansion engines of the vertical inverted type, balanced according to the Yarrow, Schlick, Tweedy system. They are placed in two separate compartments, divided from each other by a central bulkhead, and are designed to develop 20,000 indicated horsepower at 125 revolutions per minute, with a boiler pressure of 210 pounds per square inch.

The diameters of the high-pressure, intermediate, and of each of the two low-pressure cylinders are, respectively, 39⅜ inches, 64½ inches, and 74¾ inches. The stroke is 46 inches. All the cylinders have steam jackets. The high-pressure and intermediate-pressure cylinders have piston valves, while the low-pressure cylinders have double ported slide valves, with compensators at the back. Simple balance cylinders are fitted, both to the piston and to the slide valves. The valve gear is of Stephenson link-motion type. The reversing engine is of the all-round type. The pistons, cylinder covers, steam chest covers, bed plates, and columns are of cast steel, the pillars being of wrought steel.

The arrangement of cylinders from forward aft is: Low-pressure, high-pressure, intermediate-pressure, low-pressure. The distance between the forward low-pressure cylinder and the high-pressure cylinder is 84¼ inches; the same distance is between the intermediate and the last low-pressure cylinder, while the distance between the high and the intermediate is 163 inches.

The crank shafts are of steel and hollow. Each is composed of two parts, and there are two cranks on each part. Each crank shaft has six main bearings, of 14 feet 2½ inches total length. The outside and inside diameters of the crankshafts in the bearings are, respectively, 18⅜ inches and 9⅝ inches. The diameter of the crank pins is 19 5/16 inches, and their length 22 7/16 inches. The turning wheel is fixed on the coupling at the after end of the engine.

The length of the connecting rods is 92 inches, and the minimum diameter of the solid connecting rods of the high and intermediate-pressure cylinders is 9 inches; the connecting rods of the low-pressure cylinders have the same diameter, but are hollow, the inside diameter being 5 5/16 inches. The outside diameter of the piston rods is 9 inches; the low-pressure rods are hollow, the inside diameter being 4 inches. The outside diameter of the pillars is 8 inches, and the inside diameter 4 inches. The main steam pipe is 13¾ inches in diameter, and

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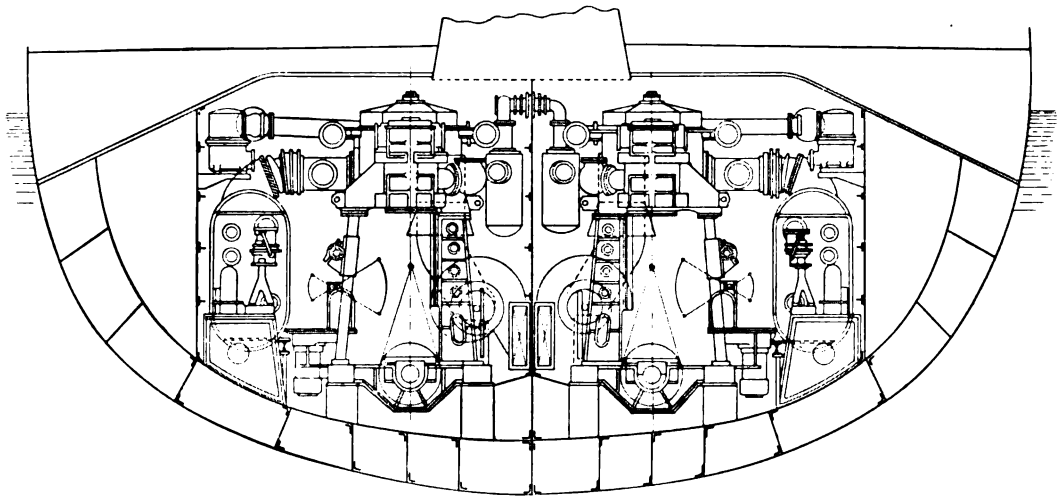
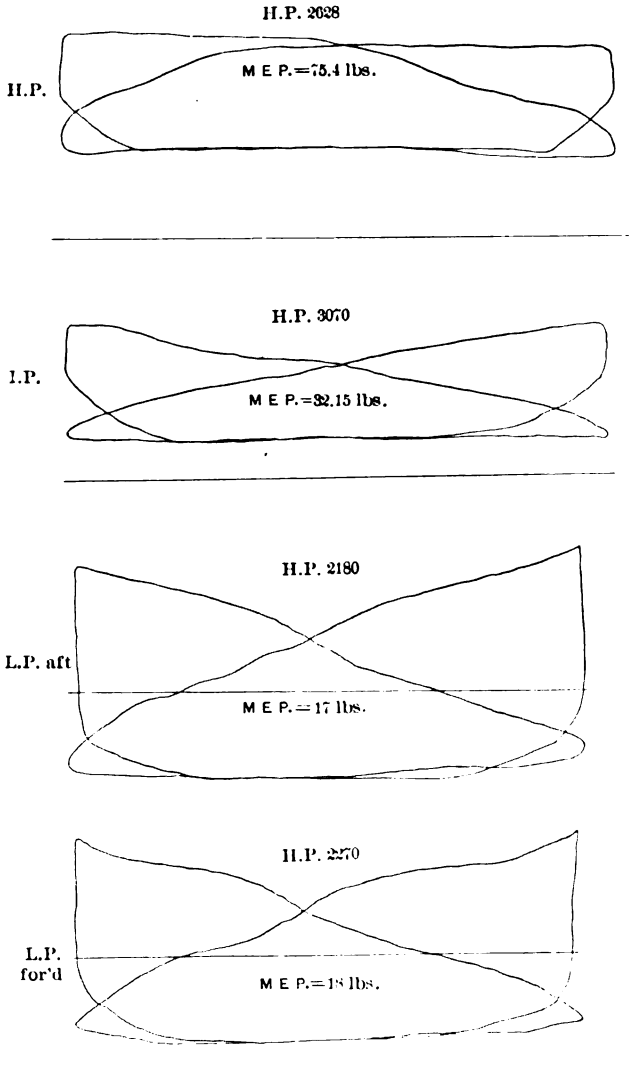


SECTION IN ENGINE ROOM, LOOKING FORWARD.

the diameter of the pipe between the high and intermediate-pressure cylinders is 20⅞ inches. Four 15¾-inch pipes bring steam from the intermediate-pressure cylinder to the two low-pressure cylinders. The diameter of thrust shaft is 18⅜ inches outside and 9⅝ inches inside. Each thrust shaft has eight collars, with a thrust surface of 17 square feet. The screw-shafts have a diameter of 18¾ inches. The propellers are of manganese bronze with three blades each. Their diameter is 17 feet 8½ inches; the mean pitch 20 feet 4 inches, and the developed surface 79½ square feet.



INDICATOR CARDS FROM THE ENGINES OF THE ROMA. TOTAL HORSEPOWER, 10,148; REVOLUTIONS PER MINUTE, 124.8.

There are four main condensers, two for each engine room, with a total cooling surface of 22,066 square feet. In each engine room the circulating water is supplied by two centrifugal pumps, driven by compound engines. Each pump is capable of delivering the circulating water to each of the two condensers independently or to both of them, and to draw from the bilges 1,000 tons of water per hour. There are in each engine room, also, two air pumps of the Weir type. One single air pump is also driven directly by each propelling engine from the high-pressure crosshead. There is also in each engine room an auxiliary condenser of 1,184 square feet.

The revolution counters are of the Molinari type. The other auxiliaries placed in the engine room are as follows: Two Ansaldo's evaporators complete with pumps, each capable of supplying 40 tons of fresh water during twenty-four hours; two independent bilge and fire pumps; two main, two auxiliary hot-well pumps and four fans.

There are eighteen Babcock & Wilcox watertube boilers, arranged in three compartments, situated forward of the engine room. The after and central compartments each contain six boilers of twenty-two elements, and the forward compartment six boilers of nineteen elements. The total heating surface is 56,467 square feet, and the total grate surface 1,636 square feet. There are three funnels, having a total area of 252½ square feet. The height of the funnels above the grate-bars is 95 feet.

Two Weir feed pumps are placed in each boiler compartment, each being capable of supplying the water necessary for all the boilers in its compartment. Forced draft of the closed-stokehole system is obtained by means of twelve fans. There are, besides, six See ejectors with three duplex pumps for expelling the ashes, and six electrical ash hoists. The main and auxiliary steam pipes are of solid drawn steel.

The first full-power sea trial took place between Spezia and Genoa, Aug. 8. The speed measured while the ship was developing her maximum power (about 21,000 horsepower) was about 22½ knots, and the coal consumed 1½ pounds per horsepower.

We may add that the *Roma's* hull is of steel throughout. The armor, which is face hardened, is distributed as follows: A 10-inch waterline belt, extending the length of the machinery space, tapering to 4 inches at the ends; a central redoubt of 8-inch armor, and a 3⅛-inch protective deck, worked in forward. The large turrets have 10-inch armor, and the smaller turrets 6-inch armor.

She carries two 12-inch, twelve 8-inch, eight 3⅛-inch and

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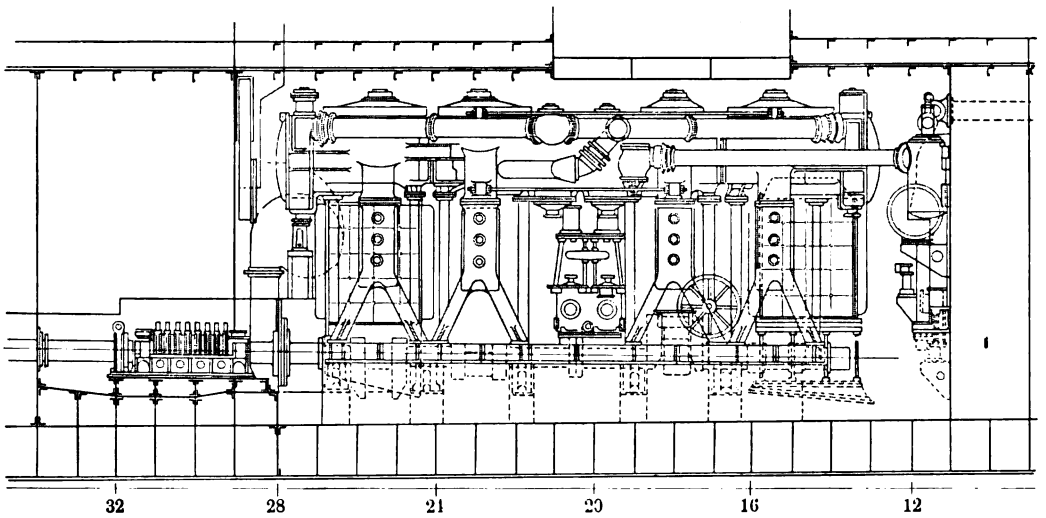
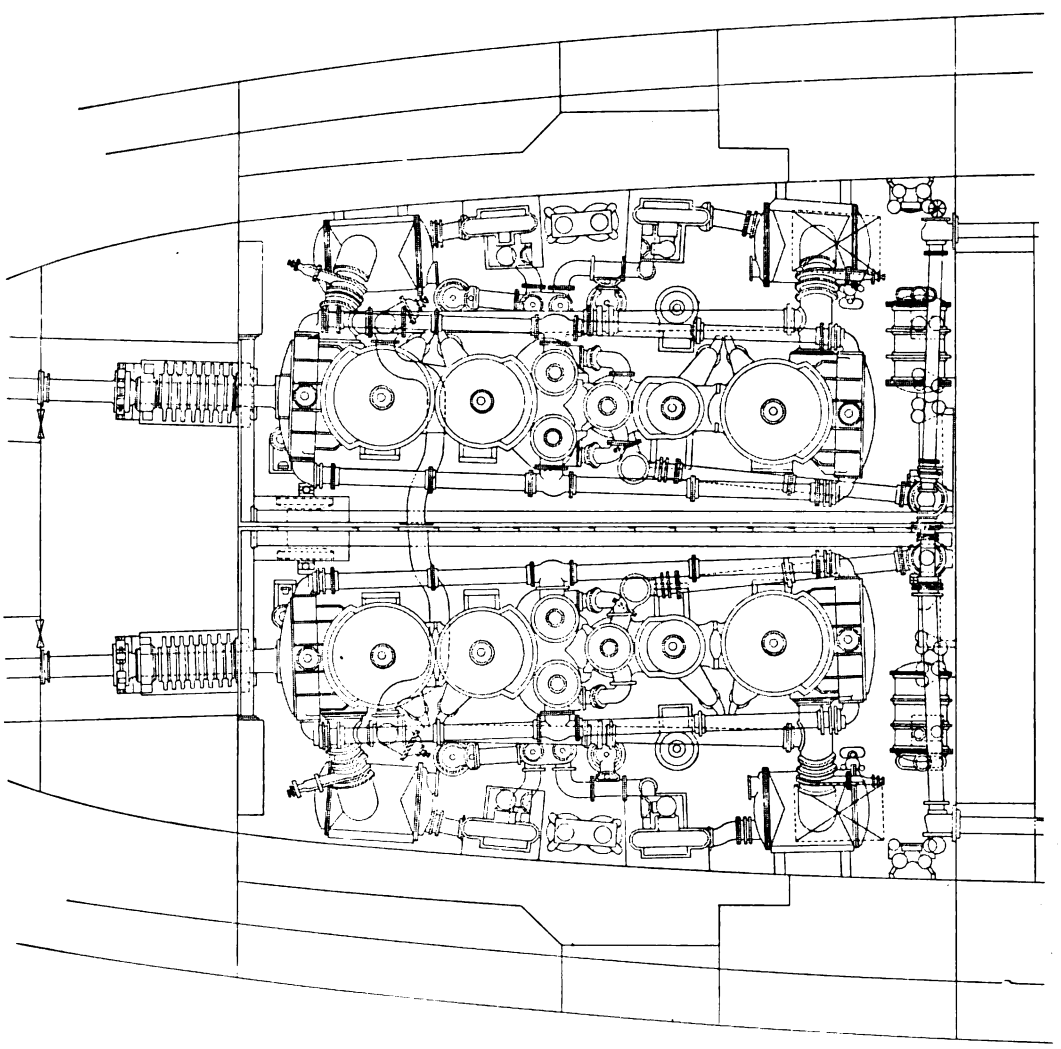
twelve 1⅞-inch guns, and is provided with two submerged torpedo tubes. Her ordinary bunker capacity is 1,000 tons, and the maximum capacity 2,000 tons. The 12-inch guns are mounted in turrets, one forward and one aft. The 8-inch guns are mounted in pairs in turrets amidships. Four of the 3⅛-inch guns are mounted in barbettes, two at the bow and two at the stern, while the rest are located in various commanding positions, distributed over the whole vessel.



SECTION THROUGH ENGINE ROOM



PLAN OF ENGINE ROOM.

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THE DESIGN OF TURNING ENGINES.

BY EDWARD M. BRAGG, S. B.

POWER OF TURNING ENGINE.

The power of the turning engine must be such that the work delivered to the crank shaft of the main engine shall equal this. The quantities involved in the development and transmission of the power are as follows:

$$\frac{\pi d^2}{4} \times mep \times 2s \times n \times n_1 \times e \times e_1 \times e_2 \qquad (3)$$

where d = diameter of turning engine cylinder in inches.
mep = mean effective pressure upon the piston of the turning engine.
s = stroke of turning engine in inches.
n = number of teeth on small worm wheel.
n_1 = number of teeth on large worm wheel.
e = efficiency of small worm wheel.
e_1 = efficiency of large worm wheel.
e_2 = efficiency of turning engine.

This can be put into the form:

$$\frac{\pi d^2}{4} \times .75P \times 2s \times n \times n_1 \times .4 \times .4 \times .8 \qquad (4)$$

And when equated to (2) can be reduced to the form:

$$d^2 s = \frac{D^2 \times MEP_t \times S}{n \times n_1 \times P} \times 63.0 \qquad (5)$$

where P = initial pressure absolute at turning engine.

The force acting upon the teeth of the small worm wheel at the pitch circle will be:

$$F = .75P \times \frac{\pi d^2}{4} \times 2s \times .8 \times \frac{1}{p} \times .6 \qquad (6)$$

Where p = pitch of teeth on small worm in inches,

$$\text{Let } Z = .75P \times \frac{\pi d^2}{4} \times s \qquad (7)$$

$$\text{Then } F = .96Z \times \frac{1}{p} \qquad (8)$$

The force acting upon the teeth of the large worm wheel at the pitch circle will be:

$$F_1 = \frac{2}{3} F \times \frac{p \times n}{p_1} \times .6 \qquad (9)$$

where p_1 = pitch of teeth on large worm in inches.

$$\text{Therefore } F_1 = .384\ Z \times \frac{n}{p_1} \qquad (10)$$

The turning moment in inch pounds upon the main engine crank shaft will be:

$$M_1 = \frac{2}{3} F_1 \times \frac{n_1 p_1}{2\pi} = .041\ Z\ n\ n_1 \qquad (11)$$

The turning moment in inch pounds upon the shaft of the large worm will be:

$$M = F \times \frac{n p}{2\pi} = .153\ Z\ n \qquad (12)$$

In the case of the large worm wheel whose diameter is limited by the height of the engine bed:

$$p_1 = \frac{C \pi S}{n_1} \qquad (13)$$

where C is a coefficient whose value varies from 1.1 to 1.5.

Therefore

$$F_1 = .384\ Z \times n \times n_1 \times \frac{1}{C \pi S} = .122\ Z \times n \times n_1 \times \frac{1}{C S} \qquad (14)$$

Since Z is a function of Pd^2s, it will be seen by referring to equation (5) that for a given engine Znn_1 is a fixed quantity, hence the force acting upon the teeth of the large wheel can be reduced only by increasing C.

If we assume that the force at the pitch circle is taken by two teeth, the stress at the root of the teeth of the small worm wheel will be:

$$f = \frac{F\ l\ 6}{2d\ t^2} = \frac{4.2\ F}{C_1\ p^2} \qquad (15)$$

Where l = length of teeth below pitch circle = $.35\ p$.
b = breadth of teeth at root = $C_1\ p$ (C_1 varies from 2 to 2.5).
t = thickness of teeth at root, assumed to be $.5\ p$ for teeth whose thickness at the pitch circle = $.48\ p$.

The stress at the root of the teeth of the large worm wheel will be:

$$f_1 = \frac{F_1\ l_1\ 6}{2b_1\ t_1^2} = \frac{2.91\ F_1}{c_1\ p_1^2} \qquad (16)$$

$l_1 = .35p_1$, $b_1 = c_1\ p_1$ where c_1 varies from 2. — 2.5.

t_1 is assumed to be $.6\ p_1$ when thickness of teeth at pitch circle = $.48\ p_1$.

To determine the number of teeth n_1 on the large worm wheel, we have from equation (16):

$$f_1 = \frac{2.91\ F_1}{c_1\ p_1^2}, \text{ but } F_1 = \frac{.122\ Z\ n\ n_1}{C S}, \text{ and } p_1 = \frac{C \pi S}{n_1}$$

Therefore

$$f_1 = \frac{Z\ n\ n_1^3}{27.7\ C_1\ C^3\ S^3}, \text{ or } n\ n_1^3 = \frac{27.7\ f_1\ C_1\ C^3\ S^3}{Z}$$

$n\ n_1 = r\ m$

Therefore

$$n_1^2 = \frac{27.7\ f_1\ C_1\ C^3\ S^3}{Z\ r\ m} \qquad (17)$$

$$n = \frac{r\ m}{n_1}$$

n should not be less than 25, preferably 30.

Referring to equation (5), it will be seen that the denominator of equation (17) is a fixed quantity for a given engine [see also equations (1) and (7)], so any variation in the number of teeth, and consequently in the pitch of the large worm wheel, will have to be made by varying the stress f_1, the tooth breadth factor C_1, and the wheel diameter factor C. In short-stroke engines, where the diameter of the large worm wheel will have to be small on account of the lack of space between the shaft and inner bottom, the wheel will be rather broad and of large pitch. If possible, it is well to have the stress at the root of the teeth not more than 3,500 for cast iron and 5,000 for cast steel. In short-stroke engines the value of f_1 can be 4,000, and wheels have been designed with $f_1 = 4{,}500$. It is advisable to make the worm wheels of cast iron and the worms of steel, as these work well together and the worm has more wear on it than the wheel. If the teeth of the worm and wheel are of equal thickness at the pitch circle, the stress at the root of the worm teeth does not need to be figured, as the worm teeth will be thicker than those of the wheel. When the teeth

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are of unequal thickness, the stress at the root of the worm teeth should be figured also. When the wheel is made of cast steel, the worm should be of bronze, as cast steel and wrought steel do not work well together.

CALCULATIONS.

We will design a turning gear for the engine whose calculations were carried through by the author in previous issues of INTERNATIONAL MARINE ENGINEERING in an article on "Marine Engine Design."*

Indicated horsepower = 3,000. Piston speed = 850 feet per minute. Boiler pressure = 185 gage. Cylinder sizes and stroke, 23½ inches, 41 inches, 64 inches by 42 inches. Let the main engine be turned over once in eight minutes, the turning engine making 250 revolutions per minute. Then, from equation (1), $n\,n_1 = 8 \times 250 = 2{,}000$.

From equation (5), $d^2 s = \dfrac{(64)^2 \times 2.5 \times 42}{2{,}000 \times 65} = 208.$

Let $s = 6$ inches, then $d = 5.9$ inches; use 6 inches.

The mean effective pressure of the turning engine will be $.75 \times .65 = 49$ pounds, and the area of the cylinder 28.3 square inches.

$Z = 49 \times 28.3 \times 6 = 8{,}325$-inch pounds.

We will make the worm wheel of cast iron and the worms of mild steel. Let the stress at the root of the teeth be not more than 4,000 pounds in the large worm wheel, the breadth of the wheel not more than 2.5 p_1 and the diameter of the pitch circle 1.5 S. From equation (17),

$$n_1^2 = \frac{27.7 \times 4{,}000 \times 2.5 \times (1.5)^3 \times (42)^2}{8{,}325 \times 2{,}000} = 4{,}145.$$

$n_1 = 64.4$; use 64 teeth.

$$n = \frac{2{,}000}{64} = 31.2; \text{ use 31 teeth.}$$

From equation (13),

$$p_1 = \frac{1.5\,\pi\,42}{64} = 3.085 \text{ inches; use 3.25 inches and reduce the breadth of wheel.}$$

From equation (10),

$$F_1 = \frac{.384 \times 8{,}325 \times 31}{3.25} = 30{,}550.$$

From equation (16),

$$C_1 = \frac{2.91 \times 30{,}550}{4{,}000 \times (3.25)^3} = 2.11.$$

$2.11 \times 3.25 = 6.87$ inches; use 7 inches breadth of wheel.

From equation (16),

$$f_1 = \frac{2.91 \times 30{,}550}{2.15 \times (3.25)^3} = 3{,}920 \text{ pounds.}$$

Diameter of pitch circle of wheel $= \dfrac{64 \times 3.25}{\pi} = 66.2$ inches.

For the small worm wheel we will use a pitch of 1.75 inches and let the breadth be $2.0 \times 1.75 = 3.5$ inches.

Then from equation (8),

$$F = \frac{.96 \times 8{,}325}{1.75} = 4.570 \text{ pounds.}$$

Then from equation (15),

$$f = \frac{4.2 \times 4{,}570}{2.0 \times (1.75)^2} = 3{,}140 \text{ pounds per square inch.}$$

This wheel can be made narrower if it is desirable, as the stress is low, or the pitch could be slightly reduced. The diameter of the small worm wheel will be:

$$\frac{1.75 \times 31}{\pi} = 17.28 \text{ inches.}$$

The indicated horsepower of the turning engine will be:

$$\frac{2 \times 49 \times .5 \times 28.3 \times 250}{33{,}000} = 10.5 \text{ indicated horsepower.}$$

The mean twisting moment on the crank shaft of the turning engine will be:

$$\frac{63{,}000 \times 10.5}{250} = 2{,}650\text{-inch pounds.}$$

The maximum twisting moment will be $2 \times 2{,}650 = 5{,}300$-inch pounds.

On the assumption that the bending moment is equal to one-half the twisting moment, and that the allowable stress on the shaft is 7,500 pounds per square inch, we get for the diameter:

$$\text{Diameter} = 1.17 \times 1.72 \sqrt[3]{\frac{5{,}300}{7{,}500}} = 1.79 \text{ ins.; use 1.875 ins.}$$

The factor 1.17 was obtained from the following table given by Unwin:

$$\frac{\text{Bending moment}}{\text{Twisting moment}}$$

	.25	.50	.75	1.0	1.25	1.5	1.75	2.0	3.0
Factor—	1.09	1.17	1.26	1.34	1.42	1.49	1.56	1.62	1.83

The small worm is to be keyed to the shaft so the diameter at the root of the thread = 1.875 + 1.1 × 1.75 = 3.80 inches; use 3.75 inches.

Length of tooth flank = .35 × 1.75 = .618 inch; use .625 inch.

Length of face = .3 × 1.75 = .525 inch; use 5 inches.

Diameter of pitch circle of worm = 3.75 inches + 1.25 inches = 5 inches.

Extreme diameter of small worm = 6 inches.

$$\text{Angle of thread} = \tan^{-1} = \frac{1.75}{5\,\pi} = .1113 = 6.35 \text{ degrees.}$$

The crank shaft for the turning engine was designed to resist a twisting moment equal to twice the mean, and a bending moment equal to half the maximum twisting moment. The shaft of the large worm is not subject to such variations in twisting moment, as the fly-wheel on the crank shaft will cause this moment to be more uniform. The ratio of bending moment to twisting moment will depend upon the breadth of the wheel, and the radius of its pitch circle. In this case the half breadth of the wheel is 3.5 inches and the radius about 8.5 inches, so the bending arm will be about .5 times the twisting arm. Since the stresses are more uniform, the allowable fibre stress can be increased to 9,000 pounds.

From (12), $M = .153 \times 8{,}325 \times 31 = 39{,}460$-inch pounds. Assume the maximum twisting moment = 39,460 × 1.25 = 49,325-inch pounds. Diameter of shaft =

$$1.17 \times 1.72 \sqrt[3]{\frac{49{,}325}{9{,}000}} = 3.525 \text{ inches; use 3.50 inches.}$$

Diameter of worm at root of thread = 3.5 + 1.1 × 3.25 = 7.075 inches; use 7 inches.

* See INTERNATIONAL MARINE ENGINEERING, July, 1908—March, 1909.

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Length of flanks = .35 × 3.25 inches = 1.14 inches; use 1.125 inches.

Length of faces = .3 × 3.25 = .975 inch; use 1.0 inch.

Pitch diameter of worm = 7 inches + 2.25 inches = 9.25 inches.

Outside diameter of worm = 9.25 inches + 2 inches = 11.25 inches.

$$\text{Angle of thread} = \tan^{-1} = \frac{3.25}{9.25\,\pi} = .112 = 6.4 \text{ degrees.}$$

The velocity of the small worm at the pitch line will be:

$$\frac{250 \times \pi \times 5}{12} = 327.4 \text{ feet per minute.}$$

The force acting normal to the teeth is 4,570; force × velocity = 4,570 × 327.4 = 1,496,218. Referring to Mr. Lewis' experiments, it will be seen that the worm will be likely to work without cutting for the short periods that the engine will run.

THE STRENGTH OF KNEES AND BRACKETS ON BEAMS AND STIFFENERS.*

BY HERMAN R. HUNT

An examination of the midship sections of various United States naval vessels by the author showed that, in general, the depth and riveting of knees and brackets at the ends of beams and stiffeners are regulated by the depths of the beams and stiffeners, although the shapes, weights, and strength vary to a considerable extent. It was therefore thought interesting to investigate the strength of the knees and brackets at the ends of the various beams and stiffeners.

Since the case of stiffeners and beams with brackets at the ends is like that of beams with knees at the ends, we will consider in this article the case of beams supported by knees at the ends.

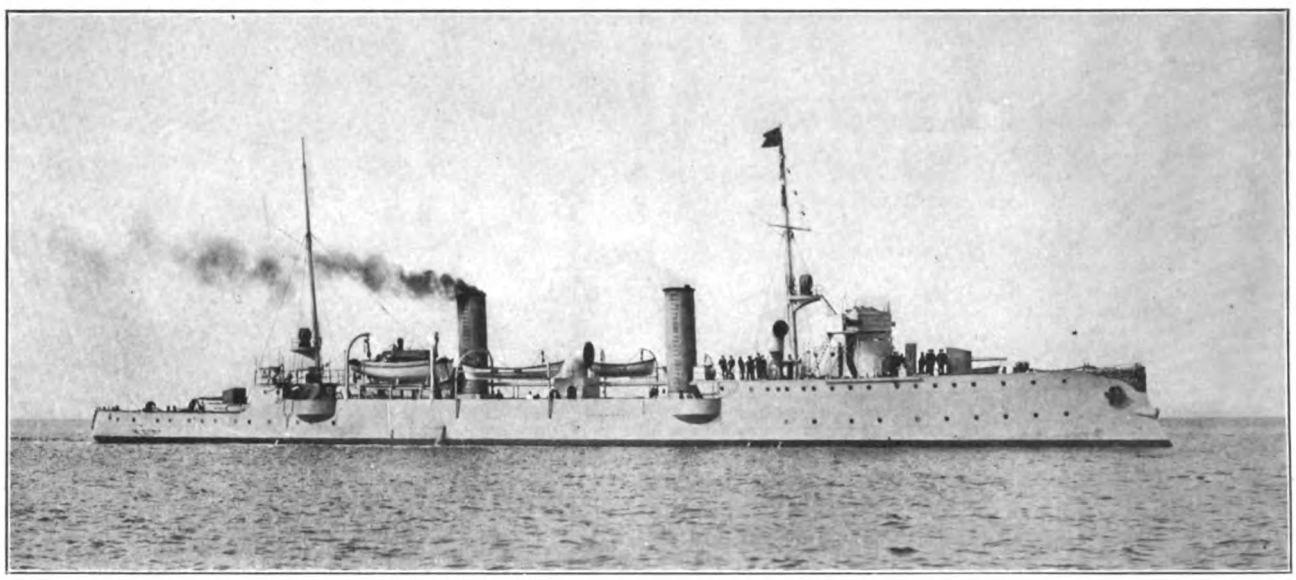
The beams and knees investigated are given in Table I. and by sketches on page 429. The riveting in the beam knees of the *Olympia, Nashville,* and *Dubuque* was assumed from the practice found in the other ships, and some of our leading shipyards, for the same sized beams. In all other respects, the data is taken from work as actually installed in the ships named.

In general, this table shows, in columns 1 to 7, that the practice in United States naval vessels is to make the depths of knees three times the depths of beams, and to use one ¾-inch rivet in the knees per inch depth of the beams. The exceptions to this statement are the 6-inch beams of the *Salem,* and the 5-inch beams of the *Vermont.* For comparison, the number and size of rivets required by Lloyd's Rules for the same knees are given in columns 8 and 9, and are determined entirely from the depths of the knees.

The strength of knees at the ends of a beam depends to a great extent on the depth and the thickness of the knees, and the number of rivets placed therein, and must be considered with reference to the strength of the beams supported.

The rivets and plating in the knees must be able to resist the shearing and crushing forces caused by loading the beam to the point of rupture. Rupture by shearing or crushing may be caused either by the concentration of a load at one

* Read before the American Society of Naval Architects and Marine Engineers, June, 1909.



22-KNOT TORPEDO CRUISER FOR THE OTTOMAN NAVY.

The Turkish Torpedo Cruiser Peik-i-Schevket.

The Ottoman navy has recently been augmented by a high-class torpedo cruiser, known as the *Peik-i-Schevket.* This vessel, together with her sister ship, *Berk-i-Satvet,* were built for Turkey at Kiel-Gaarten by the Fried. Krupp Aktiengesellschaft Germaniawerft. They have a gross registered tonnage of 702 tons each, and are propelled by twin screws, driven by vertical triple-expansion engines of 6,000 indicated horsepower. The principal dimensions of the hull are: Length, 262 feet 5 inches; breadth, 27 feet 6½ inches, and draft, 8 feet 2.5 inches.

The total displacement at the trial trip trim was 775 tons, and the speed attained 23 knots, or 1 knot in excess of the contract speed. The cruisers have a steaming radius of 3,240 miles, having a coal supply of 240 tons.

These new Turkish war vessels have an armament consisting of two 4.13-inch guns, also two Hotchkiss quick-firing guns, together with two 1.46-inch guns and half a dozen 2.25-inch guns. The torpedo armament includes one bow tube and two deck tubes, all for 17.7-inch torpedoes.

Both boats were laid down in 1906 and completed in 1907. The *Berk-i-Satvet* attained a speed of 23.1 knots on trial.

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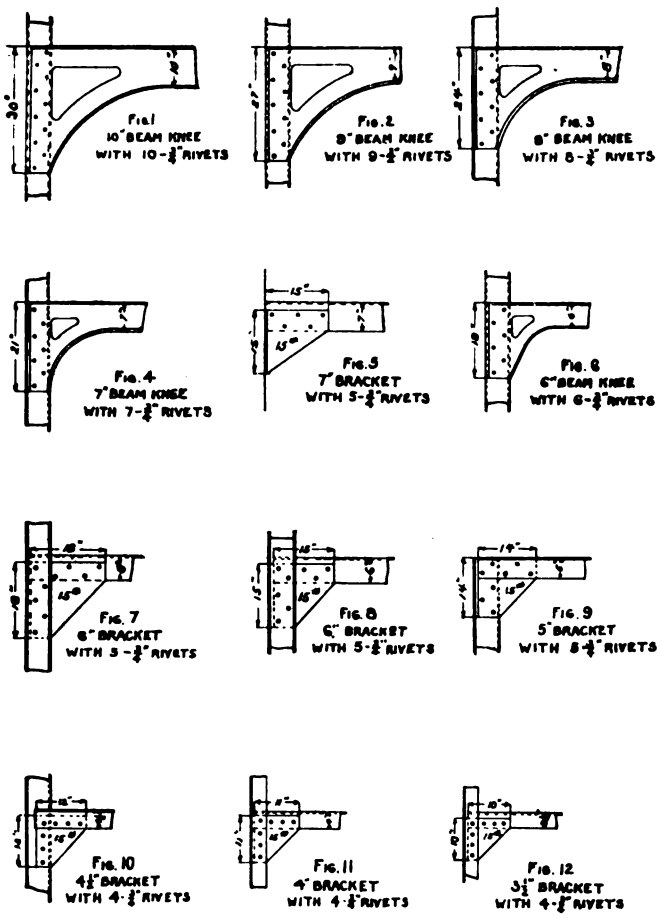

BEAM KNEES AND BRACKETS TAKEN FROM PRACTICE.

end of the beam or by the combination of the forces due to loading the beam between the supporting knees.

If the load is concentrated at the end of a beam, the shearing and crushing forces are uniformly distributed among the rivets, and are vertical. If the beam is loaded between the supports, the shearing and crushing forces are the resultants of the vertical forces due to the load, which are uniformly distributed among the rivets, and the horizontal forces, due to the bending moment, which are distributed among the rivets in proportion to their distance from a pole through the center of gravity of the area of all the rivets.

Columns 10, 11, and 13 of Table 1 show that, with the knees ordinarily used in the United States naval vessels, the resistance to shearing of the rivets in the majority of cases is from 60 to 80 percent of the resistance to shearing of the beams. The resistance to shearing of the rivets would therefore limit the load that could be concentrated at the end of a beam under ordinary conditions. This load is, however, large in comparison with the load that can be concentrated at the middle of the beam, even when considered with the weight of the beam itself. The deck beams of the *Vermont* are 10 inches by 3⅜ inches by 3⅜ inches by 21.8 pounds, and are allowed to have a maximum span of 18 feet between supports. Under this condition, the load which, when concentrated at the middle of the span, will rupture the beam by bending is 16.7 tons. This load added to the weight of the beam, 0.18 ton, gives a total load of 16.88 tons. From the table, column 11, we find that the rivets in one knee have a resistance to shearing of 98.6 tons, and will support a load six times as large as the total load given above.

The vertical stresses on the rivets, due to loading the beams at the middle, were found to be small when compared with the maximum horizontal stresses due to the bending moments. The resultants of the stresses, due to the loads and bending moments, were found to be but little larger than the stresses due to the bending moments alone. In the above case of the *Vermont's* deck beam, the following stresses were found:

	Due to Load, Tons per Square Inch.	Due to Bending Moment, Tons per Square Inch.	Resultant Stresses, Tons per Square Inch.
Shearing stress	1 91	18.09	18.13
Crushing stress in front of rivets	1.50	28.43	28.47

The differences between the resultant stresses in the table and the stresses due to the bending moment are less than one-half of 1 percent of the resultant stresses. Since these differences are so small, the stresses due to the loads have been neglected. The resisting moments of the beams and the riveting in the knees only have been compared.

TABLE I.—COMPARISON OF STRENGTH OF BEAMS WITH STRENGTH OF KNEES AND BRACKETS, TAKEN FROM PRACTICE.

Name of Ship.	Beam: Type of Section.	Beam: Size.	Beam: Thickness.	Depth of Knee or Bracket.	Ratio = Depth Knee / Depth Beam	Number of ¾-Inch Rivets as in U. S. Navy.	Figure Number.	Rivets Required by Lloyd's: Number.	Rivets Required by Lloyd's: Diameter.	Load to Shear, Tons: Beam.	Load to Shear, Tons: Rivets, U. S. N.	Load to Shear, Tons: Rivets, Lloyd's.	Ratio = Shear Rivets / Shear Beam: U. S. N.	Ratio = Shear Rivets / Shear Beam: Lloyd's.	Bending Moment to Produce Rupture in Foot Tons: Bending Beam.	Shearing Rivets, U. S. N.	Shearing Rivets, Lloyd's.	Crushing in Front of Rivets, U. S. N.	Crushing in Front of Rivets, Lloyd's.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
*Olympia	Angle	10"×3½"×26.5 lbs.	31/64"	30"	3	10	1	7	7/8"	164.8	98.6	94.0	.60	.57	535	559	571	683	598
Vermont	Channel	10"×3½"×⅜"×21.8 lbs.	3/8"	30"	3	10	1	7	7/8"	136.4	98.6	94.0	.72	.70	453	559	571	683	598
Rhode Island	Bulb angle	9"×3½"×21.8 lbs.	7/16"	27"	3	10	2	6	7/8"	134.6	98.6	80.6	.74	.60	375	498	473	710	495
Rhode Island	Bulb angle	8"×3½"×19.23 lbs.	13/32"	24"	3	8	3	6	7/8"	120.1	78.8	80.6	.66	.67	290	396	406	525	425
Rhode Island	Bulb angle	7"×3"×18.25 lbs.	7/16"	21"	3	7	4	5	7/8"	111.6	69.0	67.2	.62	.60	244	294	312	360	327
Vermont	Angle	7"×3½"×15 lbs.	7/16"	21"	3	7	4	5	7/8"	90.8	69.0	67.2	.76	.74	133	294	312	360	327
Vermont	Channel	6"×3½"×3½"×15 lbs.	0.35"	18"	3	6	5	6	3/4"	93.3	59.1	59.1	.63	.63	196	224	224	273	273
Salem	Channel	6"×1.92"×1.92"×8 lbs.	0.20"	18"	3	7	6	5	3/4"	50.2	69.0	49.3	1.37	.98	106	250	191	163	125
*Nashville	Bulb angle	6"×3"×13.75 lbs.	3/8"	18"	3	6	5	5	3/4"	83.9	59.1	49.3	.70	.59	158	224	191	273	234
Rhode Island	Bulb angle	6"×3"×12.3 lbs.	5/16"	18"	3	6	5	5	3/4"	76.8	59.1	49.3	.77	.64	149	224	191	273	234
Rhode Island	Angle	6"×3½"×13.5 lbs.	7/16"	18"	3	6	5	5	3/4"	81.2	59.1	49.3	.73	.61	101	224	191	273	234
Vermont	Angle	5"×3"×9.8 lbs.	3/8"	18"	3 9/10	6	7	5	3/4"	57.6	59.1	49.3	1.03	.85	60	224	191	273	234
Des Moines	Angle	4½"×3"×9.1 lbs.	3/8"	12"	2 2/3	4	8	4	3/4"	53.3	39.7	39.7	.75	.75	49	99	99	121	121
*Dubuque	Angle	4"×3"×8.5 lbs.	3/8"	10"	2 1/3	4	9	4	3/4"	49.1	39.7	39.7	.81	.81	39	78	78	90	90
*Dubuque	Angle	3½"×3"×6.6 lbs.	5/16"	10"	2 6/7	4	9	4	3/4"	38.6	39.7	39.7	1.03	1.03	26	78	78	90	90

* Number of rivets assumed from practice on U. S. Naval vessels.

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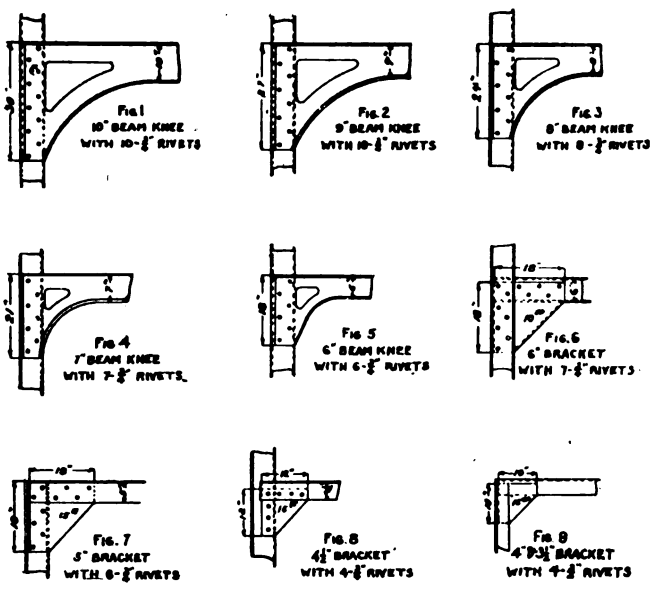
CONTINUATION OF TABLE I.

Name of Ship.	Ratio = Riveting Moment / Beam Moment			
	Shearing, U. S. N.	Shearing, Lloyd's.	Crushing, U. S. N.	Crushing, Lloyd's.
	20	21	22	23
*Olympia	1.05	1.07	1.28	1.12
Vermont	1.23	1.26	1.57	1.37
Rhode Island	1.33	1.26	1.89	1.32
Rhode Island	1.37	1.40	1.81	1.47
Rhode Island	1.21	1.28	1.48	1.34
Vermont	2.21	2.35	2.71	2.46
Vermont	1.14	1.14	1.39	1.39
Salem	2.36	1.80	1.62	1.18
*Nashville	1.42	1.21	1.73	1.48
Rhode Island	1.50	1.28	1.83	1.57
Rhode Island	2.21	1.89	2.70	2.32
Vermont	3.77	3.18	4.55	3.90
Des Moines	2.02	2.02	2.47	2.47
*Dubuque	2.00	2.00	2.31	2.31
*Dubuque	3.00	3.00	3.46	3.46

* Number of rivets assumed from practice on U. S. Naval vessels.



BEAM KNEES AND BRACKETS RECOMMENDED.

The resisting moments of the beams were calculated without taking into account the deck plating riveted to the beams, but considering one ¾-inch rivet hole in the shorter flanges at the sections of the beams. The deck plating was omitted because of the wide variation of thickness used on the same beam under different conditions.

Columns 15, 16 and 18 of Table I. give the moments required to rupture the beams and cause failure of the riveting by shearing or crushing of the metal. For comparison, the moments that will cause failure of the riveting required by Lloyd's Rules for the same knees are also given in columns 17 and 19 of the same table. These moments were calculated by the formula $f = \frac{My}{I}$, where f equals 63,000 pounds per square inch tensile stress, 50,000 pounds per square inch shearing stress, and 96,000 pounds per square inch crushing stress, and are expressed in foot-tons. The moment of inertia of the rivets in every knee has been taken about a pole through the center of gravity of the area of all the rivets in the knee.

Columns 16, 17, 18 and 19, show that the riveting of beam knees as required by Lloyd's Rules gives approximately the same resistance as the riveting according to the ordinary practice in United States naval vessels. In general, however, the riveting for knees having a greater depth than 18 inches, as required by Lloyd's Rules, is slightly stronger than that used in United States naval vessels, and the riveting for knees having a depth of 18 inches and less, as required by Lloyd's Rules, is somewhat weaker than that used in United States naval vessels. If we exclude the last four beams and the protective deck beam of the *Olympia*, the resisting moments of the riveting have a ratio to the resisting moments of the respective beams varying from 1.14 to 2.21 for United States naval vessels, and .97 to 2.35 for Lloyd's Rules in the case of shearing, and from 1.48 to 2.71 for United States naval vessels, and 1.18 to 2.46 for Lloyd's Rules in the case of crushing the metal in front of the rivets. The largest ratios occurred in the 7-inch and 6-inch angle bars.

The variations in the above ratio appear too large. It seems more logical to design the riveting and depth of knee in such a way that the ratio of the resisting moments of the rivets to the resisting moment of the beam shall be kept between more narrow limits. It is recommended that these limits be made 1.20 and 1.60 for shearing, and 1.30 and 1.80 for crushing the

TABLE II.—COMPARISON OF STRENGTH OF BEAMS WITH STRENGHTH OF KNEES AND BRACKETS RECOMMENDED FOR USE.

Beam.			Depth of Knee or Bracket.	Ratio = Depth Knee / Depth Beam.	No. of ⅞" Rivets.	Figure No.	Load to Shear. Tons.		Ratio = Shear Rivets / Shear Beam.	Bending Moment to Produce Rupture-Ft. Tons.			Ratio = Rivet Mom. / Beam Mom.	
Type of Section.	Size.	Thickness.					Beam.	Rivets.		Bending Beam.	Shearing Rivets.	Crushing in Front of Rivets.	Shearing.	Crushing.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bulb angle	10"×3½"×26.5 lbs.	31/64"	33"	3.3	11	..	164.8	108.5	.66	535	661	751	1.24	1.40
Channel	10"×3½"×3½"×21.8 lbs.	⅜"	30"	3	10	1	136.4	98.6	.72	453	559	683	1.23	1.57
* Channel	9"×3½"×3½"×20.5 lbs.	⅜"	27"	3	9	2	127.0	88.8	.70	388	457	558	1.18	1.44
Bulb angle	9"×3½"×21.8 lbs.	7/16"	27"	3	9	2	134.6	88.8	.65	375	457	651	1.22	1.74
*Channel	8"×3½"×3½"×18.7 lbs.	⅜"	24"	3	8	3	116.0	78.8	.68	319	396	485	1 24	1.52
Bulb angle	8"×3½"×19.23 lbs.	13/32"	24"	3	8	3	120.0	78 8	.66	290	396	525	1 37	1.81
*Channel	7"×3½"×3½"×17.0 lbs.	⅜"	21"	3	7	4	106.0	69 0	.65	254	294	309	1 16	1.22
Bulb angle	7"×3½"×18.25 lbs.	7/16"	21"	3	7	4	111.6	69.0	.62	244	294	360	1 21	1.48
Angle	7"×3½"×15 lbs.	7/16"	15"	2 1/7	5	5	90.8	49.3	.54	133	158	226	1 19	1.70
Channel	6"×3½"×3½"×15 lbs.	0.35"	18"	3	6	6	93.3	59.1	.63	196	224	273	1 14	1 39
Bulb angle	6"×3"×13.75 lbs.	⅜"	18"	3	5	7	83.9	49.3	.59	158	191	244	1 21	1.54
Bulb angle	6"×3"×12.3 lbs.	5/16"	18"	3	5	7	76.8	49.3	.64	149	191	203	1 28	1.36
Angle	6"×3½"×13.5 lbs.	7/16"	15"	2½	5	8	81.2	49.3	.61	101	158	226	1.56	2.24
* Channel	5"×3"×3"×12.6 lbs.	⅜"	16"	3 1/8	5	..	77.2	49 3	.64	126	168	208	1.33	1 65
Angle	5"×3"×9.8 lbs.	⅜"	14"	2 4/8	5	9	57.6	49.3	.85	60	144	177	2 40	2 95
Angle	4½"×3"×9.1 lbs.	⅜"	12"	2 2/3	4	10	53.3	39.7	.75	49	99	121	2 02	2 47
Angle	4"×3"×8 lbs.	⅜"	11"	2 3/4	4	11	49.1	39.7	.81	39	88	103	2 26	2.64
Angle	3½"×3"×6.6 lbs.	5/16"	10"	2 3/7	4	12	38.6	39.7	1.03	26	78	90	3.00	3.46

* Proposed new shapes.

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metal in front of the rivets in the knees of all beams deeper than 5 inches. For beams 5 inches in depth and less, it is recommended that sufficient rivets be used to close the joint efficiently without fixing the maximum value of the above ratios.

Table II. and the sketches on page 430 have been prepared in accordance with the above recommendations. The desired ratios of resisting moments have been obtained by varying the depth of the knees or the number of rivets. In this table ¾-inch rivets have been used for all beam knees, but, had any beam been of a thickness outside of the limits requiring ¾-inch rivets, it would have been necessary to use rivets of appropriate diameter for that thickness, and modify the number of rivets in order to keep the ratios of the resisting moments of the riveting to the resisting moment of the beam within the prescribed limits.

These results hold good for both knees and brackets used on either beams or stiffeners.

In the case of brackets, the rivets should be so disposed that the brackets will be equally strong along both riveted sides.

The comparison between the resistances of a beam subjected to bending and the shearing of the rivets in its knees by twisting was originally done under the direction of Professor W. Hovgaard for use in the instruction of the assistant naval constructors at the Massachusetts Institute of Technology. The results of this comparison convinced the author that they would be of interest to this society. He therefore investigated the resistance of the metal to crushing in front of the rivets. The tables therefore show a comparison between the resistance of the beam and the resistance of the riveting in the beam knees to shearing and crushing of the metal in front of the rivets, when the whole beam is subject to bending.

MACHINERY AND PIPING ARRANGEMENTS ON BOARD SHIP--I.

BY JOHN M'COLL.

THE BOILER ROOM.

The machinery arrangement, in connection with a vessel to be built, is usually the first drawing made by the engineers. It deals with the position and relation of the engines and boilers to the ship; with hatches, casings, bunkers and watertight doors; with the position of the funnel or funnels, screen bulkheads and entrances, etc. This drawing is made to a scale of ¼ inch to the foot, and should be as complete as possible. Such parts as boiler stools, angles for platforms and gratings, strong beams and air screens, can be shown in detail, and should be given to the shipbuilders, thus avoiding the giving of separate detailed drawings later.

In beginning an arrangement drawing the specification should be read over very carefully. Some specifications leave no doubt as to what is required, but should the information given be meagre, or open to question, notes should be taken of each item, and these so arranged that they may be submitted to the superintendent at the first opportunity. If the job in hand is in some respects similar to others already completed, and if the items in question can be settled by the manager, it will be a help to make a list headed as shown, filling in under the different engine numbers what has been done in each case.

Items.	No. 241.	No. 260.	No. 273.	New No.
Feed pipes.	Copper.	Copper.	Steel.	.....

The usual drawings supplied by the shipbuilders, on which to start the work, are a profile from the machinery space aft to the rudder post, and one or two sections. If the engines are near the stern, or if the ship fines quickly in way of the engines, more sections will be required, especially should there be many auxiliaries in the engine room.

In general, the engines and boilers should be close together, so that the steam, feed water and other connections may be short, and the supervision of the stokehold simplified. Their relative positions, however, depend on many things, such as the position and capacity of the coal bunkers, watertight bulkheads, and the ship's accommodation. In high-powered ships the position of the center of gravity of the machinery, fore and aft, and vertically, is important; especially is this so in the case of fast coasting or channel steamers, torpedo-boat destroyers and cruisers.

Divide, for convenience, the machinery arrangement into two parts, the engine room and boiler room, and begin with the boiler room. The ship designers usually fix provisionally the position of the bulkheads containing the machinery space. The width of hatches and casings may also be fixed, but these can generally be modified to suit the arrangement. In ships requiring much accommodation, the designers naturally wish to use all the space they can possibly utilize; on the other hand, the engineers must see that they have sufficient room for the proper working and maintenance of their part of the ship. In cargo vessels the engineer can generally get the required room easily, but in passenger steamers he has to have good reasons for the space he occupies.

Beginning with a simple case, that of a ship with one or two boilers, the arrangement may be as that shown in Fig. 1. The boiler is fired from the forward end and has a dust-tight screen at the aft end, round it, and extending across to the ship's sides. The advantages of this position are that the back end of the boiler is in the engine room, allowing nearly all of the boiler mountings to be placed there, the engine room is kept free from dust and grit, and the bunker doors placed so as to minimize the trimming required. In fixing the distance from the bulkhead to the front of the boiler, theories may vary as to the suitable distance for a fireman to work in; but as tubes have sometimes to be renewed, it is necessary that the distance be not less than the length of the tubes. It will be found that an allowance of 9 inches over the length of tubes will satisfy ordinary requirements. The height from the floors to the underside of the boiler may vary from 3 inches in ships with no water ballast to 2 feet in ships with water ballast. In the former case it is usually the height of the deck over the boilers that keeps them low. In ordinary cases, if possible, the distance should not be less than 12 inches, so that proper care may be given to both the underside of the boilers and the tank top.

The boiler stools may be built of plates and angles. as shown in Fig. 2, or of cast iron, as in Fig. 3. The former are preferable, as they become part of the ship's structure, can be better stayed, and are lighter. Stools should be placed directly over the floors and, if this is not possible, as in the case of some double-ended boilers, a bridge piece connecting the two floors between which they rest should be fitted. Tie plates, in ships with shallow floors, should be arranged to distribute the weight of boilers over as many floors as possible, and in ships with ballast tanks the tie plates should not prevent access to the bottom of the boilers.

Pitching chocks to prevent movement fore and aft will be required, and these are best placed at the forward and aft ends. They should span two floors, and be well secured to the tank top with heavy angles. Heavy plates ¾ to 1 inch thick should be used; and for large boilers, doubling pieces to broaden the bearing surface, as shown in Fig. 4, will be an advantage. Should the height of boilers exceed 15 inches, the chocks should have a side stay. Angles for stools and pitching chocks should be riveted to the tank top early, so that the tank testing is not interfered with.

To keep the boilers in place when the ship is rolling much,

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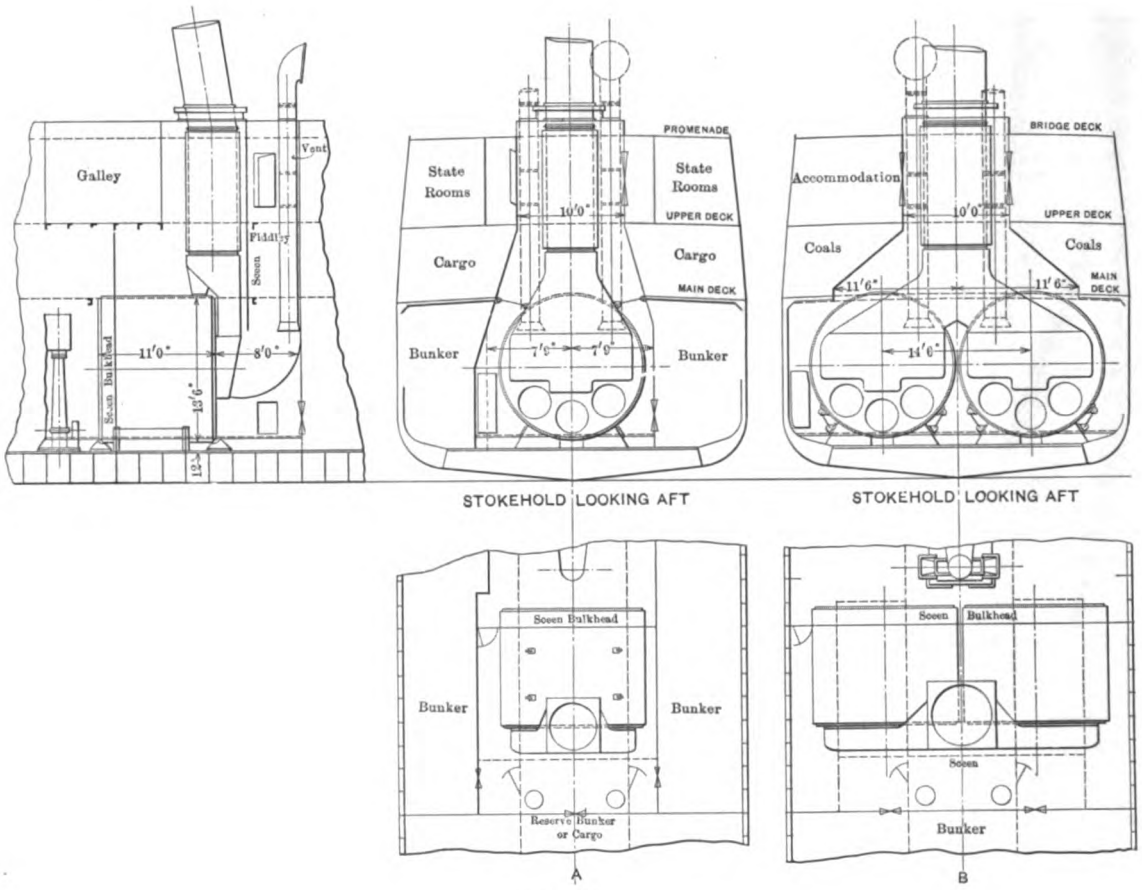

FIG. 1.

two methods may be adopted; first, that of bar stays and palms, as in Fig. 5; one palm is riveted to the boiler, the other to some rigid part of the ship, usually the deck coaming plate, as in Fig. 1A, or to the boiler stools, as in Fig. 1B. In Fig. 1B the stays need not be round bars with forked ends, but could be cut from plate, say, 1 inch thick by 4 inches broad, doubled. Another method to prevent movement is that

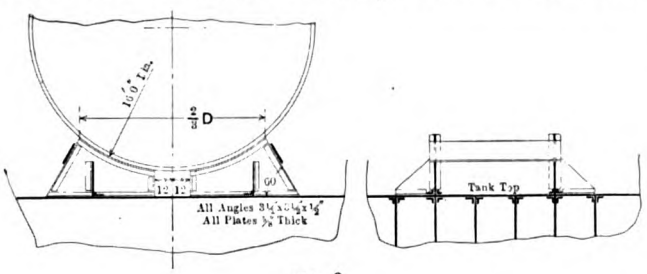

FIG. 2.

shown in Fig. 6. Care in this case must be taken to sufficiently stiffen the bunker side.

In arrangements with two or three boilers abreast, the distance between each will depend on whether the passage from engine room to stokehold, or stokehold to stokehold, is to be

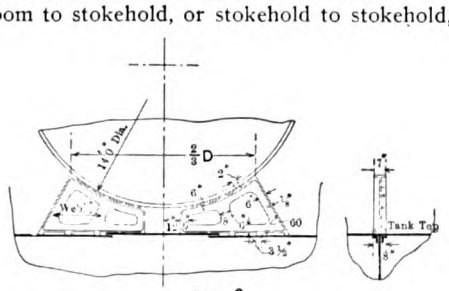

FIG. 3.

between the boilers or at the ship's side. If the passage is at the side, the distance between boilers should be at least sufficient so that each can be properly lagged; but if the boilers are required to be very close together, the butt straps can be kept out of the way, and the rivets in the circumferential seams at the center line countersunk. In any case the passage should be large enough to allow a man to pass through upright; and if possible, it should be on the same side as the engine starting platform.

In fixing the distance between boilers facing each other, whether single or double-ended, the ventilators, air trunks (if forced draft), the position, and means of access to the gage glasses and other mountings, all have to be considered, and

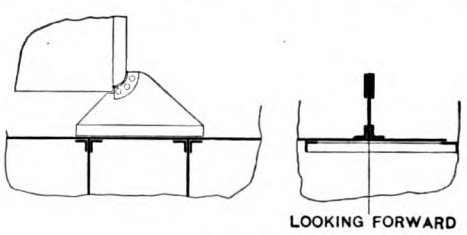

FIG. 4.

as these vary in each ship, a set distance is not easily fixed. However, it is found that from 11 to 13 feet between boiler fronts gives a fair stokehold. In placing single-ended boilers with their backs to each other, or to a bulkhead, room should be left sufficient to allow a man in to do slight repairs. If back to back, as in Fig. 7, the distance should not be less than 18 inches, as, with about 3 inches covering on each, the space would then be 12 inches. If the back end is next a bulkhead, the same distance should be maintained, to allow for bulkhead stiffeners.

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Auxiliary boilers, whether connected or not to the main steam system, should, if convenient, be placed at the aft end of the stokehold, so that they may be near the pumps, etc. In other respects they are dealt with as main boilers. If used for winches only, they are sometimes placed on the same deck as the winches, and between the engine and funnel hatches.

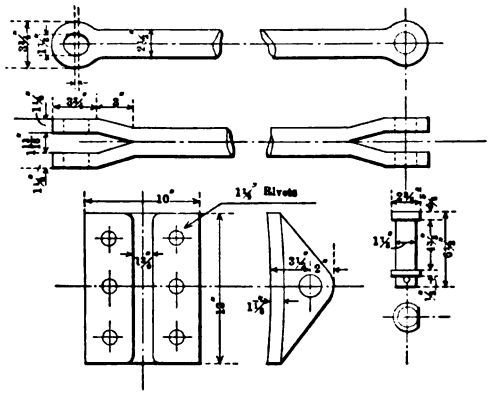

FIG. 5.

In this case, the deck supporting them has to be specially strengthened, and, owing to their elevation, extra precautions are required to prevent them breaking loose in rough weather.

As the arrangement of bunkers and casings depends so much on the type of ship, only general statements can be made here. With the boilers placed alongside a bunker, the minimum distance between them should be 9 inches. With a cross bunker between the engine and boiler rooms, passages are required for communication and for steam pipes. Should the main passage not be used as a recess for auxiliaries, its width should not be less than 36 inches, and, if fitted with a watertight door, it should also have a wood door.

When the boilers are surrounded by bunkers, recesses or passages to the ship's sides are required for the blowoff cocks, firemen's water-service cocks, and the ash ejector pump and sea suction valve. One frame space is usually sufficient for these recesses, and the height need not be more than necessary to give access to the cocks and valves.

In arranging the boiler casings, the engineer's first care should be to provide sufficient room for the boiler mountings, main and auxiliary steam pipes, etc., and to see that these are readily accessible. If the fiddleys are to give access to the stokeholds, they must be large enough to admit the use of sloping ladders, and care should be taken to see that the ventilators and fan trunks, if any, do not block the natural air

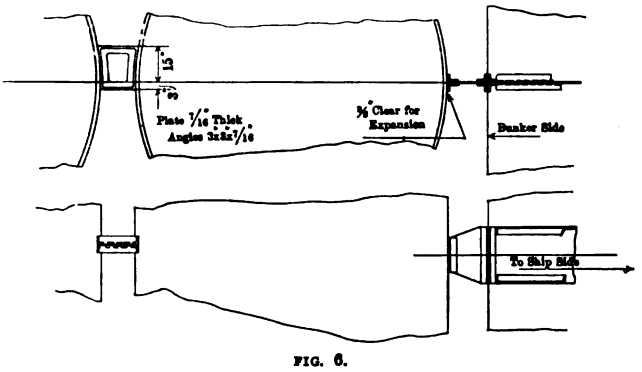

FIG. 6.

supply to the stokeholds. If the outer funnel only is to be supported by the casings, as in Fig. 7, bracket plates are fitted, and if the whole funnel is to be supported, as in the largest vessels, the arrangement may be similar to that shown in Fig. 8. In the latter case, the inner funnel has a simple sliding joint as its base, the lowest tier of riding plates between the funnels being riveted to both, and the remainder to the inner funnel only. This allows for the different expansions. The outer funnel brackets rest on the casing, strong beams and brackets taking the whole weight off the smoke-boxes and

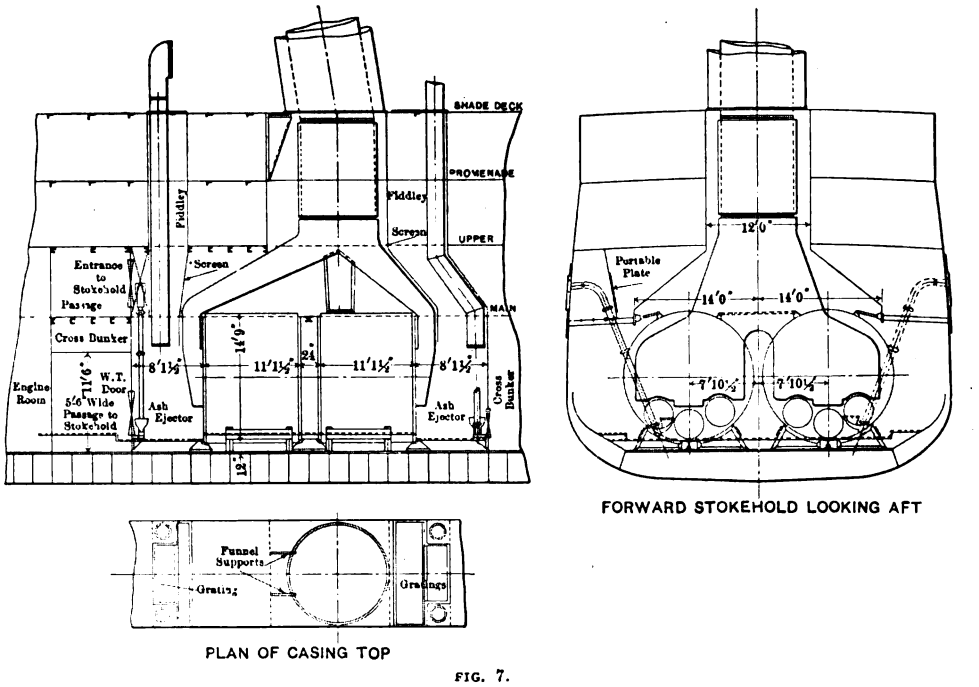

FIG. 7.

boilers. The screen bulkheads, or air screens, should be carried down as far as possible, to prevent the tendency of the air supply to make a short circuit instead of going to the furnaces.

The position of the fans for assisted draft is usually at the fiddley top, with air trunks led into the ventilators. For forced draft the fans may be at the top or bottom of the fiddley. At the top their supply of air is right, but long trunks are required to reach the boilers. They are too much out of the way of the engineers, and, if they make any noise or cause vibration, they may be a source of complaint from the passengers. At the bottom of the fiddley, they are near their

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work, easily attended to, and out of the way of passenger accommodations. Proper seating and heavier scantlings can also be used here, and vibration will be avoided; on the other hand, unless enclosed, they will get their share of the stokehold dust and grit.

In closed stokehold arrangements, the fans are placed on the deck above the boilers, and the type of fan will determine whether they project through the deck or not. Fig. 9 shows an arrangement suitable for a fast coasting steamer. The difficulties with this type of ship are the lack of roof available, the smoke-boxes are crushed down, making the angles so flat that soot is allowed to lie and gets burned, causing the plates to be unduly heated. The passages to the fan rooms are awkward, and the principal boiler mountings are practically outside the stokehold.

The angle of the underside of the smoke-boxes should not be less than 35 to 37 degrees, and there should be no flat parts.

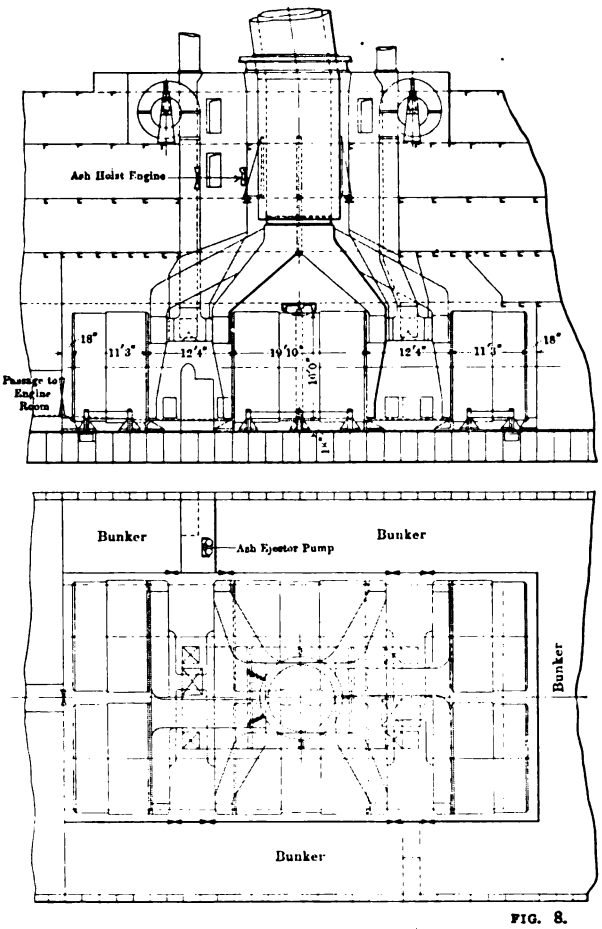
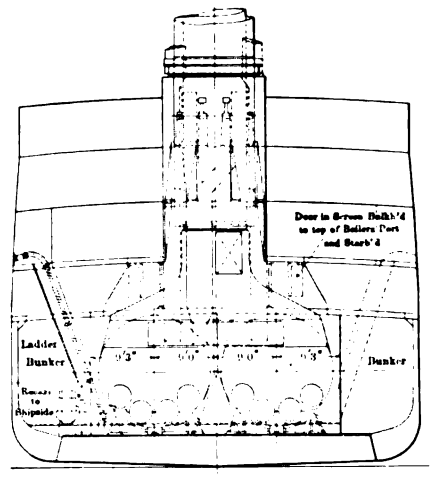


FIG. 8.



AFT STOKEHOLD LOOKING FORWARD

The smoke-box should be supported from the boilers, not by beams or the casings. If there is more than one boiler, the smoke-box area for each should be a little more than its share of the funnel. The inner funnel area may be one-fifth the total grate area. The diameter and height of the outer funnels are usually made to suit the appearance of the ship. If the funnel is not to be double, an air casing should be fitted up to where it commences to rake aft, and should be 6 to 8 inches greater in diameter. The lower part of the breakwater should suit the hole in the casing top, and may be 9 inches clear of the funnel all around, the upper part projecting at least 3 inches beyond, and being attached to the funnel.

The fiddley top is filled in with grating, except for as much as will support the ventilators. In very heavy weather the grating may be covered over with canvas or sheet-steel plates. The ventilators would then be the only source of natural air supply, so that these must be ample to meet this requirement. They should be carried down to about 8 feet from the stokehold floor and, if the lower ends foul the smoke-box doors when open, may be made to telescope, or hinge out of the way. If used as ash hoists, they should be bell-mouthed and fitted with wood runners. For ordinary requirements the cowl diameter is twice that of the body. The thickness of body is from 14 to 12 L. S. W. G., and the cowl from 12 to 10 L. S. W. G.

Unless in the largest ships, where the boilers may be at a distance from the engine room, it is not necessary to provide for feed pumps in the stokeholds. The ash ejector pump, however, is suitably placed there and, if convenient, the recess for blow-off cocks may be enlarged to receive it. The number of ejectors will be fixed by the specification, but they should be placed equally on both sides of the ship. The segments at the top must be accessible from the stokeholds or at the place for changing and renewing these, and for attending to the valve. The means for getting there will vary, but two ways are shown in Figs. 7 and 8.

The ash-hoist engines are placed high up in the fiddley and, if no ash chute is fitted, they should be at a deck where there is easy access to the ship's side for tipping the ashes overboard.

Ladders and gratings ought to be arranged to give the easiest passage to the parts requiring them. Vertical ladders should be avoided, and it is better to have shorter ladders with landings than very long ladders. The usual width of stokehold ladders is 18 inches, and the main ones should be double sparred. The gratings vary in width to suit their positions; but where single-width gratings are used, these should not be less than 18 inches broad.

(To be continued.)

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PROPER METHODS OF OPERATING AND CARING FOR A YARROW WATERTUBE BOILER IN ORDER TO GET THE GREATEST EFFICIENCY.

In considering the subject of the relative merits of Scotch and watertube boilers, the fact is frequently stated that the watertube boiler requires excessive coal consumption. Whenever this is true, it is due largely to mismanagement of the boiler, rather than to any inherent fault of the boiler itself. Excessive coal consumption of watertube boilers is usually due to the fact that too little coal has been consumed per square foot of grate surface. The elasticity of construction of the watertube boiler makes it fully able to stand forcing, usually is in Scotch boilers, it is impossible to obtain like results. The need of a training school for stokers for such boilers is very urgent.

The reason for burning a large amount of coal, rather than a small quantity per square foot of grate area, is because combustion is more complete when rapid. The temperature of the furnace is also maintained at a higher point, thus insuring complete combustion before the gases pass through the tubes. It is true that in some designs of watertube boilers, slow combustion may be necessary, because in such designs, if the rate of combustion is very high, the heat absorbed by the lower row of horizontal tubes may be too great for the capacity of the tubes for generating steam, consequently the

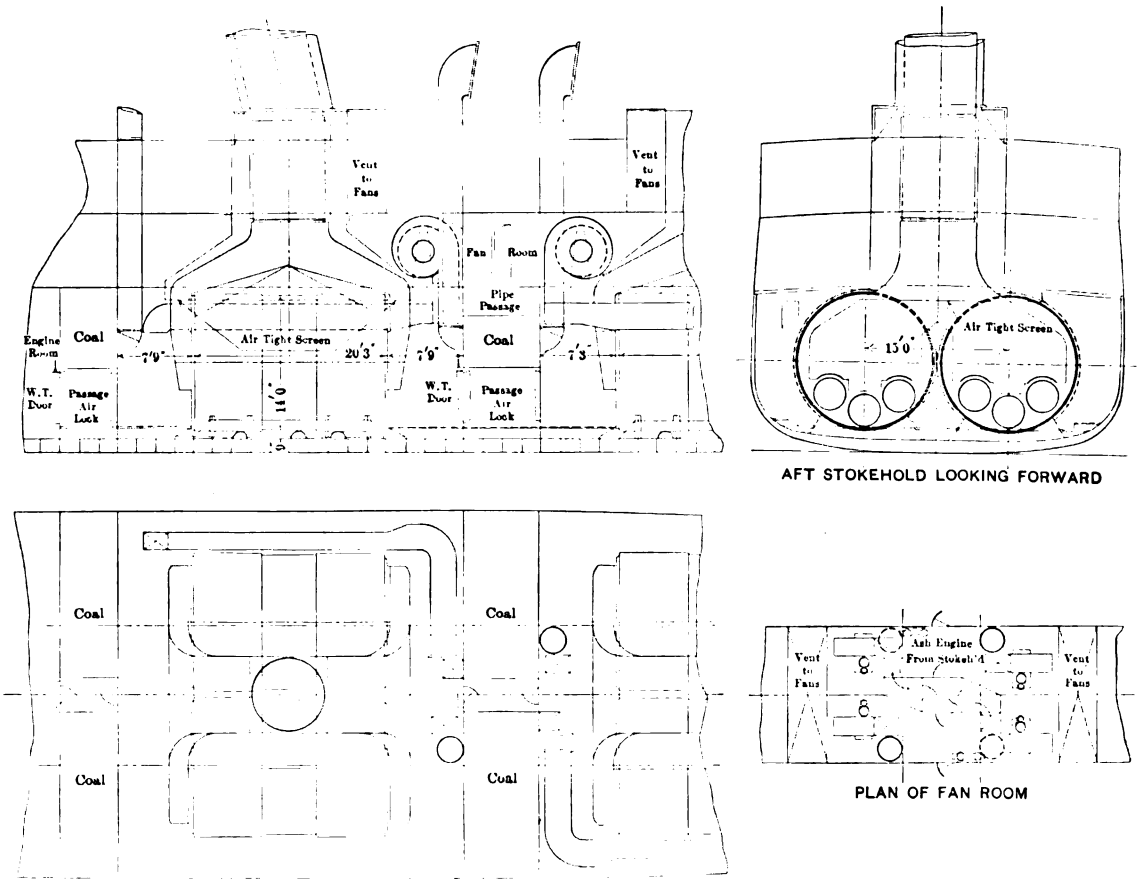

FIG. 9.

and, therefore, greater efficiency and economy are likely to be obtained by burning, say, 40 pounds of coal per square foot of grate area in a few boilers than by using 20 or 30 pounds per square foot on a much larger grate area. Undoubtedly it is easier work for the stokers to use a greater number of boilers and to run them without forcing, but, where this is done, it is extremely likely that uniform firing will not be carried on, and that holes in the fires will be found, through which the cold air will enter, thus producing incomplete combustion and causing undue loss of heat.

In an ordinary Scotch boiler, each furnace has only about 21 square feet of grate surface, and, therefore, it is not a difficult matter for an ordinary fireman to keep the grate completely covered with coal. On the other hand, in many watertube boilers 50 or 60 square feet of grate surface are frequently included in a single furnace. To fire such a furnace, which is usually from 7 to 8 feet long, requires, not only considerable skill, but it necessitates conscientious work. Right here is where much of the inefficiency which has been laid to the fault of the watertube boilers really exists. Until stoking in watertube boilers is carried out as efficiently as it tubes are liable to become overheated and rupture. In the case of the Yarrow boiler, however, this possibility does not exist, owing to the inclined tubes, which permit the steam to pass rapidly to the steam drum, thereby setting up automatically a vigorous circulation. This circulation is enhanced by ample downcasts, and, therefore, practically the only thing which can cause overheating of the tubes is the obstruction of some tube, which, of course, would not be likely to happen if the boiler were properly cleaned and inspected.

With proper firing, the coal consumption of the Yarrow boiler can be made highly satisfactory. The main reason why good economy can be obtained with this type of boiler is because the combustion chamber is large, permitting an intimate and proper mixture of air with the gaseous carbon and giving time for complete combustion of the gases before they pass among the tubes.

RENEWAL OF TUBES.

The replacing of tubes in the Yarrow boiler is a matter that can be very easily carried out, and any defective tube can be removed and replaced in a few hours without disturbing the

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boiler. It is, of course, most important to be able to clean readily the outside of the tubes in any watertube boiler, since deposits of soot and dirt soon decrease the efficiency of the heating surface. The tubes of the Yarrow boiler can be cleaned in three directions: from the front between the tubes, from the furnace, or from the casing outside. Furthermore, since the tubes are all straight, with the possible exception of the two rows next the fire, which are sometimes slightly bent, the tubes can be examined internally throughout their entire length. This can be carried out most conveniently by means of a small electric light, which can be passed through the tubes, giving an opportunity for careful examination of the interior surfaces from the mud drums to the steam chest.

In the event of renewing tubes, the question of spare gear is not a vexatious one for the engineer, since the tubes are all of uniform diameter.

The tubes are secured to the tube plates by the usual expanded joint, which has stood the test of time as practically the best joint which can be made in a boiler shop. Leakage can be practically overcome if the tubes are properly expanded. The end of the tube should project through the plate for a length of about 3/16 inch. This projecting end should then be turned over to an angle of 45 degrees. This can be done by means of a special forming tool, the operation being called "bell-mouthing." If a tube should split in belling, it should at once be rejected as unfit for service. Great importance is attached to the bell-mouthing, and it has been found that tubes thus securely attached to the plate cannot creep, or in any way move in the tube holes.

INSTRUCTIONS FOR LAYING UP THE BOILER.

When laying up a Yarrow boiler, it is advisable that it should be emptied and drained of water and thoroughly washed out internally with clean, fresh water. Ashes and any accumulation of soot should be removed from the tubes and tube plates. This is of the utmost importance, because if moisture becomes absorbed by the dirt which collects on the heating surface, corrosion will soon commence, and when once started will increase rapidly. The outside of the tubes may then be cleaned by means of a hose with as good a force of fresh water as is available. The casing should also be carefully swept on the inside.

To dry out the boiler a small coke fire should be lit in a suitable portable receptacle, which may be placed in the ash-pan. A portion of the fire-bars must be removed for this purpose, so that the fire can be kept far enough from the tubes to avoid overheating them. By leaving the manhole and mudhole doors off, the vapor formed in the boiler will escape.

If the boiler is to be laid up for a long period of time, quicklime in suitable trays should be placed in the upper and lower drums. The drums should then be closed up to exclude the air, care being taken to remove the lime before filling the boiler with water. The object of the quicklime is, of course, to absorb any moisture that might remain in the interior of the boiler and cause corrosion. Another reliable practice when laying a boiler up is, after it has been thoroughly washed out, to close up all manhole and mudhole doors and completely fill the boiler with fresh, clean water, adding 9 pounds of common washing soda to each ton of water, this soda being absorbed in the water before it is put into the boiler. Again, care should be taken before starting the boiler under these circumstances to thoroughly empty it. Other precautions to be taken when laying up the boiler are, to put the funnel covers on to prevent rain wetting the tubes and casings. If the boiler is to be laid up for a long time, it is also very desirable that the brickwork should be removed, and only replaced when required.

A bolted joint is provided to the lower water pockets of the smaller Yarrow boilers. The joint is made with asbestos metallic sheeting 1/16 inch thick. Before breaking this open the weight of the boiler should be carried on lugs provided for that purpose at each end of the lower tube plates. When remaking the joints of these water pockets, after having screwed the joints up as tightly as possible, steam should be raised to 10 pounds per square inch gage to thoroughly warm the boiler and then the bolts in the joints finally tightened up.

These joints should be broken only in case of important repairs.

When it is intended to raise steam, the boiler should be filled with water to the top of the gage glass and 1 or 2 pounds of ordinary lime per thousand gallons should be added in the form of milk of lime. Care must be taken that the lime is well mixed before being put in the boiler, and the lime water should be passed through a fine strainer.

When the boiler is in operation every opportunity should be taken to shut down each boiler in rotation in order to examine the brickwork and clean the tubes inside and out. The two or three rows of tubes nearest the fire require more careful attention than the others, and, if any accumulation of sediment is found, it should be removed before the boiler is started again.

PROPER METHODS OF FIRING.

In firing the boiler, a thin, even fire should be kept, taking care to keep the corners of the grate covered. There is far more risk of wasteful consumption of fuel by having too thick a fire than by having too thin a one. The thickness of the fire must, of course, be determined, to a great extent, by the kind of fuel used and the amount of forcing desired. On the average, a thickness of from 5 to 6 inches has been found to be suitable with Welsh coal. When charging the furnace the coal must be thrown on in the exact places where required, and not piled up at the front end of the grate and afterwards pushed back, as is customary with ordinary marine boilers. The ash-pit doors must always be kept shut and properly secured, so that in the event of a boiler tube bursting or steam suddenly escaping from any other cause, it may not find its way into the stokehole. For the same reason the fire doors should be kept closed, except when stoking. In the event of a serious leakage of steam, the fan should be immediately turned on to force the escaping steam up the funnel. The stokehole should be closed, the pumps turned on at full speed, and the fire extinguisher put into operation.

No oil should be allowed to get into the boiler. If any oil is used for the internal lubrication of the machinery, it should be mineral oil, although in many engines it is found that oil can be dispensed with altogether in the cylinders. As little oil as possible should be used for lubricating the piston rods, because a certain amount of this oil invariably finds its way into the cylinder, and thence to the boiler. Special care should be taken that the auxiliary engines should not be such as to involve the use of oil for internal lubrication. At all events an ample area of feed-filtering surface should be provided.

TREATMENT OF FEED WATER.

The water used in the boiler should always be distilled, and only when unavoidable should be obtained from the shore, as that will often lead to the formation of scale. Tests should be made frequently to ascertain whether there is any acid in the water or not. Not only should it be alkaline, but it must be definitely so. For this purpose from 1 to 2 pounds of ordinary line per 1,000 indicated horsepower should be pumped daily into the feed, as milk of lime, or even more, if found necessary, to insure the water being decidedly alkaline. Tests for the acidity of the water can easily be made with litmus paper. On no account whatever should sea water

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be allowed to get into the boiler. This means that special pains must be taken to see that the condensers are tight; that the evaporator does not prime; and that all sea connections are properly shut. If, however, sea water does get into the boiler, double the ordinary quantity of lime should be used with the feed, the fires must not be forced and the density kept as low as possible.

HOW TO TREAT A SCOTCH BOILER IN ORDER TO OBTAIN THE BEST RESULTS.

BY C. A. M'ALLISTER, ENGINEER-IN-CHIEF, U. S. R. C. S.

In its general characteristics a Scotch boiler is not so totally unlike a horse, or other beast of burden, as might at first be imagined. We are taught from infancy that kindness and intelligent treatment of dumb animals will bring forth reciprocal good results from our four-footed friends. While it is not proposed in this brief article to carry out the analogy between the treatment of boilers and that of horses, it is hoped that some of the ideas set forth may indicate, metaphorically speaking, the proffering of lumps of sugar to our steel shelled producers of horsepower.

In these days an ill-designed boiler of the Scotch type is the exception, rather than the rule, as might be said of boilers built some twenty or thirty years ago. This happy state of affairs has been brought about largely by an interchange of ideas and experiences through the media of boiler makers' societies, good text-books, and articles appearing from time to time in technical papers devoted to engineering subjects. While we of to-day may ridicule the products of the pioneer boiler designers, yet, on sober, second thought we must credit to their mistakes (oftentimes costly in money as well as in human life) our present knowledge, which enables us to avoid the shoals upon which they foundered. We will therefore assume that we are to handle a modern Scotch boiler in which the ratio of heating to grate surface, the size of combustion chambers, the area through the tubes, the spacing of the tubes, the proportioning of water spaces and the hundred and one other details of boiler designing have been carefully thought out, not so much from the scientific standpoint as from the data gained by the rough experiences of our predecessors.

If asked to name the most important rule as a maxim to be adopted by the man in charge of a marine boiler of the Scotch type, I would unhesitatingly say that it is "Avoid sudden changes of temperature." From the first starting of the fires until the boiler has been allowed to cool off after a long period under steam, this rule must be kept continuously in mind if the best results are to be obtained.

The necessarily thick shell plates of the modern Scotch boiler must be heated slowly in order to avoid leakage at the joints from the undue strains which accompany sudden changes of temperature. Consequently steam should never be allowed to form in a Scotch boiler under 6 hours' time from the lighting of fires, and if circumstances permit it is much better to take 8, or even 12, hours for this operation. As one of the inherent faults of all tank boilers is the large volume of "dead" water underneath the furnaces, too much stress cannot be laid upon the importance of artificially circulating the water in the boiler, either by use of the hydrokineter or other circulating devices, or by the well known and always available method (where at least one boiler is under steam) of connecting up the auxiliary feed pump to draw from the bottom blow connection and discharge through the feed-check valves. This provides a uniform heating of the boiler shell throughout, and the consequent avoidance of trouble engendered by having a volume of cold water under the furnaces while steam is being raised.

When steam is formed, the careful engineer will see that all air is expelled from the boiler before closing the air cock and the safety valve. He should also, in every instance, see that the cock in the pipe leading to the steam gage is open. This may appear to be a trifling detail, yet we must remember that only within the past three or four years a boiler explosion on an American vessel, which caused the loss of nearly two scores of lives, was directly traceable to the neglect of this very function, unimportant as it may seem.

After steam has formed, the pressure should be allowed to rise very slowly; the longer time taken the better for the boiler. After the pressure has reached the desired point, the boiler can be "cut in," and here, again, great caution must be exercised; never open the stop valves suddenly. It is always preferable to open the auxiliary stop first, and that should be just cracked from its seat until the pressures are equalized.

So much has been said and written about correct methods of firing that it is practically impossibde to bring forth any new ideas on the subject, yet it may be well to reiterate some of the generally approved maxims. Quickness in firing is most desirable, in order to minimize the time when the cold air of the fireroom is drawn in over the fires and comes in contact with the highly heated plates of the furnaces and combustion chambers. To insure this a sufficient quantity of coal should always be laid out on the floor plates immediately in front of each furnace, so that the fireman will not have to take a few steps away to reach the coal when charging the furnace, which is often the case when the coal passer has loafed on the job and dumped the coal haphazardly around the fire room. Systematic firing is undoubtedly the best, that is, each furnace should be charged in regular rotation, care being taken that no two furnace doors are opened at the same time. The same rotation should be adopted in slicing the fires. Ashes should never be allowed to accumulate in the ash-pans, as this is only a form of laziness, which results in the refuse from the grates becoming banked up so as to interfere with the draft.

The great tendency of all firemen is to get at the fires which are to be cleaned when they first come on watch, so as to get a bad job over with. Frequently it will be the case that several of them will be cleaned at one time, with the result that the steam will drop, the revolutions naturally falling off, and the speed of the ship for the first hour of a watch show a marked decrease. This should be avoided by never allowing more than one fire to be cleaned at a time; the whole number to be cleaned should be distributed uniformly throughout the 4 hours. There will then be no irregular fluctuations in the pressure, with the consequent variations of temperature; incidentally the temper of the engineer of the watch, who is striving to keep up the revolutions, will not become ruffled. All old-time firemen, and many new ones, delight in carrying "crown sheeters," as they term a furnace when it is simply stuffed with coal to its utmost capacity. This method, although it gives the fireman more time to smoke his pipe, violates all of the laws of God and man, so far as efficient combustion is concerned. Fires of a uniform thickness, from 8 to 12 inches, according to the circumstances, will be found to give the best results, and although they require a little more attention, the coal bills at the end of the month bear ample testimony of their efficiency.

When, as is bound to occur, the tubes become clogged and it is necessary to blow them out with steam, or even sweep them in extreme cases, the work should be performed with the greatest celerity. Never should more than one nest of tubes be swept or blown at a time, as nothing more deleterious can be imagined than to allow cold air to come in contact with the tube sheets for a prolonged time. Quick

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and snappy must be the work of the men handling the lance or brush as the case may be. All fire-room crews are prone to pass this disagreeable duty up to the "next watch," but it is a matter that should be attended to promptly, as the bad effects of clogged tubes are very noticeable on the steam gage and revolution counter.

It may safely be said that nine-tenths of the economical running of marine machinery begins in the fire room. The engineer who only visits the stokehold occasionally to see if the water is being carried at the proper level is not doing his duty to the steamship owners. A systematic training of the stokers in the essentials above enumerated and a rigid supervision of the fire-room force at frequent intervals will necessarily result in such a saving of fuel as will well reward the efforts put forth.

It is a well-known hygienic fact that nearly all of the diseases to which humanity is subject arise from improper feeding. The same may be said of steam boilers. If nothing ever passed through the feed-check valves but absolutely pure, hot water, there would be few, if any, troubles, with the interior surfaces. A general recognition of this fact is resulting in minimizing boiler disorders. However, from causes too numerous to mention, it is seldom possible to keep up a continuous supply of water possessing those desirable qualities. The general discontinuance of the use of cylinder oil in the main engines has removed one of the principal causes of trouble, yet, even now, it is practically impossible to run certain auxiliaries without the use of some oil. Large tank capacity and evaporating plants have solved the problem of furnishing sufficient fresh water for boiler use, yet we still have to contend with leaky condenser tubes, poorly seated manifold valves, etc., which, in spite of all precautions, allow some salt water to get into the boilers. Then, too, even the fresh water obtainable at many of our sea ports contains sufficient deleterious ingredients which cause trouble from scale deposits, etc. It is, therefore, highly essential that the engineer exercise vigilance in the care of his Scotch boilers. Nothing is more important than a daily test of the water; with the high pressures carried nowadays the old-fashioned salinometer test is not sufficient to keep him informed as to the true state of the water.

The greatest care must be exercised to keep the water in a neutral or slightly alkaline condition. The most feasible method to determine its acidity or alkalinity is the well-known litmus paper test. For a few cents sufficient litmus paper may be obtained to last for a month. No scientific knowledge is necessary to make this test; all that is essential is to draw a glass of water from the boiler and dip therein a small strip of the blue paper. If the paper turns red, the water is acid, and steps should at once be taken to neutralize it by adding an alkaline solution. Nothing better has ever been found than plain sal soda, at a cost of about 1 cent per pound. Remember, always, that electrolytic action, galvanic action, or "eating away," whichever you may choose to call it, does not occur unless an acid medium exists.

As before stated, the old-fashioned salinometer does not give the engineer sufficiently accurate data as to the amount of solid matter in the boiler water to be of much use in caring for modern boilers. In the old days of "pump and blow," saturations of 2, 2½, or even 3, were quite common, but for present purposes a saturation of ½, or even ¼, should be looked after. With the ordinary hydrometer everyone who has had experience knows how futile it is to read such small graduations. It is therefore much better to provide in the boiler outfit a small bottle of nitrate of silver; by adding a few drops of this liquid to a glass of water drawn from the boiler the smallest amount of saline matter may be detected by the cloudiness produced in the water. If an undue amount is shown, it is quite evident that salt water is getting into the boiler, and if none but fresh water has been used for "make-up" feed, it must then be concluded that the condenser tubes are leaking, or some valve in the manifold needs regrinding.

The best method for keeping oil out of the boiler is to keep it out of the feed water. If lubrication must be used in the main engine cylinders and valve chests, do not use oil, but use graphite mixed with water or kerosene. This material cannot possibly harm the interior surfaces of the boiler; on the other hand, it is probably beneficial in tending to prevent corrosion. If some oil must be used in the dynamos, feed pumps, etc., then take great care to remove it from the feed water by careful filtering in the feed tank. It takes but very little oil on the crown sheets of Scotch boiler furnaces to cause sagging, and if you have several furnaces out of round, then you have a real cause for worry. The careful engineer should, whenever a boiler is being cleaned, tram its furnaces to see if there are any signs of sagging. A drop of ½ inch can hardly be determined by even the most trained eye, and if a furnace goes beyond that limit it is liable to sag in a hurry, and generally at the most inopportune time. While furnaces which have sagged as much as 2, or even 3 inches, may run along for a time, it is certainly anything but comforting to the engineer of the watch to know that they are in that condition. The old saying of "A stitch in time saves nine," is very applicable to sagged furnaces. If they are down, for instance, only 1 inch on one trip, the next trip they may come down with a rush, so it is better to have them "jacked up" at once.

The advisability of fitting zincs to Scotch or any other kind of marine boilers is now so generally recognized that there can be no argument against such usage. In cleaning a boiler, particular pains should be taken that all zincs should be renewed where they have disintegrated to such an extent as to be useless. If sufficient metal is left in the block to warrant further use, the surfaces of the zincs should be carefully chipped or scraped, in order to present bright metal for the galvanic action. There should also be good metallic contact between the slabs and the containing baskets, as well as between the handles of the baskets and the stays to which they are attached. If this is not attended to there will be as little chance for efficient working as there would be to get a good current from a galvanic battery with poor contact at the terminals.

To cure many of the evils incident to poor management of boilers, there has been as much quackery as there was in the early practices of alleged doctors on mankind. All sort of material, such as tan bark, horse manure, potatoes, etc., have been prescribed by boiler quacks to correct certain evils. It does not seem possible that even now some engineers can be found who believe in the efficiency of these so-called "old-fashioned remedies," yet the writer has had his attention called to an instance, which occurred within the last month, where the chief engineer of a tugboat dumped two bushels of potatoes through the manhole of the boiler of which he was in charge, on the supposition that they would remove scale. Probably better results would have been obtained by giving an extra allowance of this favorite vegetable to the firemen at mealtimes. It is not intended to convey the idea that all "boiler medicines" are fakes, as it is now very generally conceded that there are several boiler compounds on the market, prepared by reputable firms from the formulæ of expert chemists, which undoubtedly are of great benefit in preventing or removing scale and in minimizing electrolytic actions.

Much more might be written on the subject of good treatment of Scotch boilers than has been outlined in this brief review of the principal methods now employed, but it is hoped that, brief as have been the foregoing suggestions, they may attract the attention of some engineers so that there may

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be even a slight improvement over the existing methods of treatment which may have been adopted for the boilers in their charge.

INSTRUCTIONS FOR THE WORKING AND MANAGEMENT OF DÜRR BOILERS.

SETTING TO WORK.

The boilers should always be filled with clean, fresh water up to slightly below the usual water level, because, when steam is raised, the bubbles of steam passing up through the water chamber cause the water level to rise considerably. Steam should be raised slowly when the boiler is heated for the first time, or when the brickwork is new; later on, steam can be raised in about 30 minutes, or as quickly as the fires can be got to work.

Care should always be taken to drain the superheater before connecting the boiler to the steam pipes; for not only is there a possibility of water being left standing in it when the boiler has been kept full, but also when the boiler has been shut off.

After the boiler has been working for a short time, the water chamber and the tube-hole doors should be carefully examined, as it is quite possible that at first some of the water-chamber doors may blow, or become leaky, as the working pressure increases. If such should be the case, the nut should be slightly loosened, and, after bringing the door into the correct position by light tapping against the cap, again screwed up.

MANAGEMENT OF THE FIRES.

The combustion should be maintained with as short a flame as possible, and should cease before the heated gases reach the tubes. There should consequently be an ample supply of air, and the fires must be kept thin. Under natural draft the thickness of the fires should be about 4 inches, and even under forced draft they should not, if possible, exceed 5 inches.

For a steady pressure of steam a uniform condition of the fires is indispensable, for the production of steam in boilers with small water chambers depends almost entirely upon the rate of combustion. The most advantageous method would consequently be a continuous, uniform feeding of the furnaces; in order to approach this desideratum as nearly as possible the fires must be fed uniformly with small quantities of coal, and at short intervals. A practical standard is a charge of 2 pounds per square foot of grate area. As the grate area behind each furnace door is usually from 10 to 13 square feet, the charge per door should consequently be from 20 to 26 pounds of coal.

If a boiler has several furnace doors, greater uniformity of stoking will be insured if the doors are served at alternate intervals. For boilers which have a number of separate furnaces each with two doors, open the first door of each furnace at regular intervals, and open the second door at the next intervals. If several boilers are in the same stokehold, the furnace doors should be numbered in such fashion so that alternately one after the other one-half of the doors shall always be served.

It often happens on board ship, whether in consequence of unequal draft in the stokehold or in the funnel, that one boiler, or one fire of a boiler, has a more powerful draft than the others, and that the fire consequently burns away more quickly; in such case the combustion should be regulated as far as practicable by means of the ash-pit, or uptake dampers. Under forced draft, however, the ash-pit doors are always to be kept fully open; the fire with the greater draft should consequently receive temporarily a larger charge, so as to keep it up to the same thickness as the others. The coal must be thrown on quickly, and the furnace doors should not be kept open a moment longer than is necessary to stoke the fires, so as to prevent too much cold air getting into the furnaces. On opening the furnace door, the stoker should see the whole grate at a glance, and decide what parts require the coal, for the smoke caused by the first shovelfull, as soon as it is thrown in, prevents the condition of the fire from being seen. The coal at the sides of the furnace burns away more quickly, in consequence of the glowing heat of the brickwork, than that in the middle; therefore the fire near the brickwork should be kept rather thicker.

CLEANING THE FIRES.

Cleaning the fires should be carried out in the same way as stoking them; viz.: with the furnace doors in series, so as to minimize any fall in the pressure of steam. If necessary, while one fire is being cleaned, the others may be slightly more heavily forced. If a fire, or a half a fire (*i. e.*, that portion of a grate lying behind a furnace door) requires cleaning, it should be worked through a few times with the rake at the usual intervals for stoking, until it becomes thin, and not till then should the cleaning begin; the work will then be easy, because the fire is thin.

The ash-pits are made watertight, and should always be kept full of water, so as to cool the ashes which fall through the bars.

CLEANING THE FIRE SURFACE OF THE TUBES.

With good coal, and when steaming under natural draft, this cleaning requires to be done every five or six days at the most. The dirt principally accumulates on the baffle plates and on the upper sides of the tubes, *i. e.*, especially where dead angles in the current of the hot gases occur. When forced draft is being used, the tubes can be cleaned in a very simple manner as follows: The boiler room with closed furnace and ash-pit doors is placed under as high an air pressure as possible, while the fan is allowed to run for some time at full speed; then first one furnace door and then the other is opened, followed alternately by the covers of the lattice wall, the strong draft thus blowing both the soot and flying ash into the chimney. It is advisable to shake the plates while blowing.

When forced draft is not being used, the cleaning is done by a steam jet. The lance is pushed in lengthways between the tubes, either through hollow stay-bolts in the water chamber from the stokehold or from behind through cleaning holes in the lattice wall covers.

Cleaning by means of steam jets should only be done while the boiler has its fires lighted and working; it should never be done with banked fires. The cleaning should be commenced from the top, because only the lighter soot passes off through the funnel, while the heavy dirt drops down below. If a very large amount of dirt should have accumulated on the baffles, it must be drawn out from behind through the lattice wall.

In course of time deposits of ashes and clinkers begin to form on the lower sides of the bottom rows of tubes, the clinkers having been carried by the forced draft from the furnaces, and driven against the tubes, to which they occasionally stick and get burnt on. These deposits must be scraped off from the furnace.

WATER LEVEL.

Generally speaking, the Dürr boilers are constructed of such water capacity, and with so large a water surface, that a check valve in the feed pipes of each boiler, placed at a convenient height, is quite sufficient to enable the water level to be kept at the right height. It must not be forgotten, however, that the water level rises and falls with the steam production of the boiler, as a result of the larger or smaller

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number of steam bubbles present in the water chamber. If, therefore, for any reason, the water level has fallen very low, and the pumps are worked quickly, the steam production, by reason of the introduction of the cold feed water, will be somewhat diminished, and, as a result, a sinking in the water level will again be brought about. The feed should consequently be regulated a little before the normal level is reached, or otherwise the water will stand too high when the development of steam again becomes normal.

Hot feed water increases the regularity of the steam production and the efficiency of the boiler, consequently efforts should be made to heat the feed water as much as possible before putting it into the boiler.

SCALE AND FOULING.

The addition of salt water to the feed has a tendency to make the boiler prime, and for this reason it must be avoided, quite apart from the deposits which it leaves in the boiler. It is necessary that the boiler water should be tested each watch. If any increase in the amount of salt present becomes apparent, and the defect cannot be discovered and remedied, care must be taken by blowing off that the amount in solution does not exceed 1 percent, or otherwise considerable precipitation will take place on the heating surfaces. With surface condensation, fouling of the feed water by the lubricants of the steam cylinders is unavoidable.

In order to neutralize the finely disintegrated fat in the feed water, and also to neutralize any acids, it is advisable to add a solution of soda or milk of lime to the feed. In using soda, however, great care must be exercised, for even a small excess of soda in the boiler water may cause the boiler to froth; not more, therefore, than 1 pound of soda should be used to 1 pound of cylinder oil.

The most effectual way, however, of preventing fouling of the boiler is to clean the feed water outside the boiler by filtering. The first essential for efficiency in the filter is that the feed water shall pass through slowly, *i. e.*, a large filtering surface is necessary.

ACTION TO BE TAKEN IF THE ENGINES ARE SUDDENLY STOPPED.

If the steam requirements are suddenly greatly diminished, or altogether stopped, the rate of combustion must also be diminished, otherwise the steam pressure will very quickly rise and the safety valves will blow. One of the first steps is to close the ash-pit doors, and if that is insufficient, to slightly open the furnace doors so as to allow cold air to enter the furnaces. Opening the furnace doors, however, must be done gradually to prevent any too sudden cooling of the heating surfaces—especially of the lower tubes; if this precaution be taken the boiler will not be injured, for the Dürr boiler, by reason of its construction, is not hurt by sudden changes of temperature. A further decrease in the production of steam can be brought about by increasing the feed; indeed, this to a certain extent will occur quite automatically; but the boilers must not be allowed to get too full.

SHUTTING OFF THE BOILER.

If the boiler is to be shut off, the first thing is to blow through all surface blow-off and sediment cocks until all accumulations of dirt have been removed, the boiler is then pumped up again to the usual level unless it needs emptying to carry out any repairs. If the boiler is to be out of use for some time, it should be pumped full for preservation. Meantime the fire is allowed slowly to burn down, so that the circulation in the boiler may be kept up as long as possible, which will prevent the dirt still remaining in the water from settling in the lower tubes.

After the fires have been drawn the grates and brickwork of the furnaces should be thoroughly cleaned from slag, then the ashes should be drawn and the water drawn off from the ash-pan; after that the furnace and ash-pit doors and the chimney dampers should be closed, and the boiler be allowed to cool down slowly. After the boiler is cool the superheater should be drained, otherwise water may remain standing in the tubes, and so cause them quickly to rust.

REGULAR INSPECTION.

Whenever a boiler is put out of use an external inspection of the lowest rows of tubes and of the brickwork in the furnace should be made.

In the Dürr boiler the tubes are only jointed to the boiler body at the front end, while the back ends lie free, and with a certain amount of play, in the lattice wall. The tubes can thus not only expand freely lengthways, but are enabled also to compensate to a certain extent for inequalities of temperature. In the lowest rows of tubes, which are exposed to the direct action of the fire, and to the radiation of the whole of the furnace, the amount of bending when the boiler is forced is so great that the top of the tubes press tightly against the lattice wall. The counter pressure on the back ends of the tubes thus exerts a frequently recurring tendency to bend, which in time brings about a permanent upward bend of the tube; the tubes when cold then lie bent (under tension) in the lattice wall. A gradual curvature of the lower tubes is, therefore, quite naturally brought about, and need give no cause for anxiety in the Dürr boiler.

On the other hand, if a sudden considerable curvature is observed to take place in the lower tubes, this is almost always a sign of extensive internal fouling. Under such circumstances immediate cleaning of the interior of the tubes is necessary.

Defective places in the brickwork should be repaired as soon as possible, and special care should always be taken that the protective arches over the furnace doors are kept in good condition.

Periodical examinations should be made to ascertain the extent of internal fouling of the boiler, because on board ships the method of working and the quality of the feed water are never so uniform that definite periods can be laid down for cleaning.

The water in the chamber is run off, and the hand-hole doors of a few tubes in the lowest row are opened; the inner tube is withdrawn, and the water standing in the outer tube is run out either with a syphon from the front or by opening the tube doors from the back of the boiler. The outer tube is then carefully inspected all along with a light, and some of the deposit is scraped off; if no deposit is found in the tubes of the bottom row one may be pretty certain that the whole of the tube nests are also free, and there is no need to continue the examination; on the other hand, if any deposit is found, it should be ascertained how far the dirt extends by taking out other tubes in different parts of the boiler. Care should always be taken to examine the bottom side tubes, because sediment easily collects there in consequence of the lesser amount of evaporation and the more sluggish circulation.

INTERNAL CLEANING.

If the deposits in the tubes have attained a thickness of 1/32 to 1/16 inch the boiler should be cleaned; if, in addition, any oil refuse (leavings) should be found in the boiler, the boiler should be boiled out with soda. To do this 1 pound of soda for every 10 feet of heating surface is put into the boiler, which is then filled up to the customary level and heated with slow fires for some 12 hours, allowing the steam, at a pressure of from 40 to 50 pounds, to blow off through the safety valves; after boiling for a few hours water should be blown out through the scum-cocks, and also from time to time through the lower blow-out valves, taking care to constantly feed up with fresh water. After the boiling out is finished the fires are drawn, and the water chambers are blown out empty through the outboard blow-off pipe. Before the boiler gets

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quite cold the water chamber hand-holes should be opened, the inner tubes drawn out, and the outer tubes should be washed, with the warm water still in them, with a round steel wire brush; then open suddenly the back doors of the tubes, each tube is at once emptied, the powerful stream of water carrying with it all the dirt which has been scraped off.

If after this cleaning there should still remain any scale in the tubes, it must be removed by scraping. The scale so scraped off is washed out by a stream of water.

Accumulations of pieces of scale will be found at the bottom of the back halves of the headers, which, after the cleaning of the tubes has been completed, should be withdrawn through the mud holes or through the lower hand-holes. On the other hand, mud and oil refuse will be found in the front halves of the headers, which can be cleaned off with turpentine or be brushed out and washed away after boiling out the boiler.

Fatty deposits on the inner tubes are most easily removed by burning off, the tubes being held for a short time in the furnace of a boiler at work. If, however, the deposits are of a more earthy nature, the inner tubes, as soon as they are taken out of a boiler, provided the mud is not yet dry, should be lightly cleaned by springing and washing off.

Part of the dirt which floats on the surface of the boiler water will remain sticking to the walls of the steam collector, where in time it will form a thick crust, which must be scraped off every time the boiler is cleaned. With rapid evaporation, and especially if any priming should occur, small portions of this dirt may be projected even beyond the steam pipe and lodged in the corners of the separator. These recesses should therefore always be watched and kept clean so as to prevent any narrowing of the sectional area. Any fouling of the superheater will only be observed under the rarest circumstances; it is therefore sufficient to carefully empty it, dry it and to slightly grease both the outer and inner tubes with cylinder oil in order to protect them from rusting.

If the layer of scale in the tubes should by any chance attain such a thickness and hardness as to be no longer removable by scraping, which may possibly happen after steaming with river water holding mud or scale in solution and making use of condensation by injection, then the tubes must be taken out for thorough cleaning.

CLEANING THE FIRE SURFACES.

After continuous working, especially with slow combustion, a tarry residue, distilled from the coal, attaches itself to the tubes and becomes more or less burnt on. This can only be removed by sweeping with very hard brushes and by scrapers after the boiler has stopped working. Cleaning should commence with the upper tubes. The tubes should first of all be swept with brushes to sweep down the loose ash from them and from the baffles; then the more tenacious crust must be scratched off with the double scraper.

The lower tubes should be cleaned, especially on their lower sides, which are exposed to the fire, and should have the slag sticking on to them scraped off; then the tubes should be carefully examined for bends and any signs of wear. The brickwork must be without cracks and fit well everywhere. Finally, the soundness of the whole lagging should be examined, and any loose places should be repaired. Special care should be taken that the back protecting doors fit well into their framings, and that the asbestos packing is in good condition; for any access of cold air to the boiler above the furnaces is accompanied by a loss of draft and efficiency.

REMOVAL AND REPLACEMENT OF HANDHOLE DOORS AND END DOORS OF TUBES.

If a header door has to be opened, after taking the nut and cap off the bolt, a special driver is placed over the bolt, and by lightly tapping it (the driver) the door is loosened and driven inwards. Before fastening up again, the bedding surface of both doors and holes should be well cleaned, and may rough places made smooth. Emery powder is only to be used when absolutely necessary, and then only very fine grained. Before replacing the doors in the holes the bedding surfaces should be lightly smeared with graphite paste; the thread on the bolts of the doors should also be lubricated with graphite before screwing on the nuts, which will considerably facilitate their subsequent removal. The doors must only be screwed up with the usual length spanner which accompanies the boiler.

In opening the tubes at the back the work must be done carefully, so as to avoid loosening the tubes in the cone seating. After the nut and cap have been removed, the door opener is placed over the bolt, the trigger fitting over the tube end where it fits in the circular collar and the door forced into the tube by turning the pressure screw. Opening by hammer blows on the door opener is strictly forbidden, because the tube might be driven out of the cone of the header wall. Long rods, which seize the doors by means of springs, are used to pull out and push in the doors from the front end of the tube.

For tubes which have outer fastening, cap, nuts, etc., it is necessary that the back tube end should be held firm. The lattice wall-cover is taken off, and a tube holder is placed over the end of the tube which fastens it on to the lattice wall. Before putting together again, all bearing surfaces and threads must be well cleaned and smeared over with graphite, so as to prevent them getting rusty.

REMOVAL AND REPLACEMENT OF TUBES.

If, on examining the boiler, it is found that any tubes, possibly in the lower rows, are too much bent—bends up to ½ inch are of no consequence—the tubes should be taken out and straightened. If a tube, however, shows any signs of swelling, which is an infallible sign of dangerous overheating of the metal, it must be changed. In order to pull out the tubes, after the inner tube and the back end door have been removed, rods are inserted in the tubes from the front, which seize the back tube end with disc trigger and wedge, and are drawn in front of the chamber with pulley and nut catch-hook. By gently tapping with a hammer against the back end of the rod, the loosening of the tube in the cone is facilitated. Driving out the tubes only by blows on the back end without the special withdrawing apparatus must be strictly prohibited, because adjacent tubes may thereby become loose in the cones.

In replacing the tubes, care must be taken to prevent any foreign matter getting in between the bearing surfaces. The tubes can be forced in either with a screw press or by hydraulic pressure. Hydraulic pressure is to be preferred, as one thereby has a greater control over the amount of pressure exercised. While being forced in, light blows should be given with a wood hammer so as to overcome the passive friction, and to bed the tube properly in the cone. New tubes are pressed into the tube holes some ¼ to 5/16 inch if the tubes have been previously bedded by light blows on a wooden plug in the cone. Tubes which have already been forced in no longer enter to such an extent with the same pressure, but only some ⅛ to 3/16 inch. With each fresh forcing in, the tube cone sets somewhat deeper in the tube hole until finally the safety collar prevents any further entry. So long, however, as the seating available for forcing in is as much as ⅛ inch, one may confidently depend upon the tube being tight, even if the safety collar touches the header wall.

If it appears when the tube is put in position that the requisite ⅛ inch of bearing surface for properly fastening the tube is not available, the tube must be taken out again and the cone expanded. The expanding of the tube cones is done by tube rollers of the ordinary construction after putting over the joint a heavy steel gage ring bored to the size of the standard cone.

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PRESERVATION OF THE BOILER.

Good preservation of the boiler can only be obtained with the boiler quite full—wet preservation—or, with the boiler quite empty—dry preservation. When it is probable that the boiler will not remain long idle and an internal cleaning is not needed, the wet preservation commends itself for choice. If the boiler is to remain unused for some time, then the dry method of preservation is preferable.

in the smaller ones by the cockpit. When there is a cabin the pilot house is situated just forward of it, above the after part of the engine room; otherwise, the steering wheel or tiller is on the after deck or in the cockpit. (See Fig. 1, showing the arrangement for a 16 brake-horsepower and Fig. 2 for a 34 brake-horsepower installation.) This location of the engine room is natural. It gives short connections between the parts for coupling and reversing and the corresponding handles at

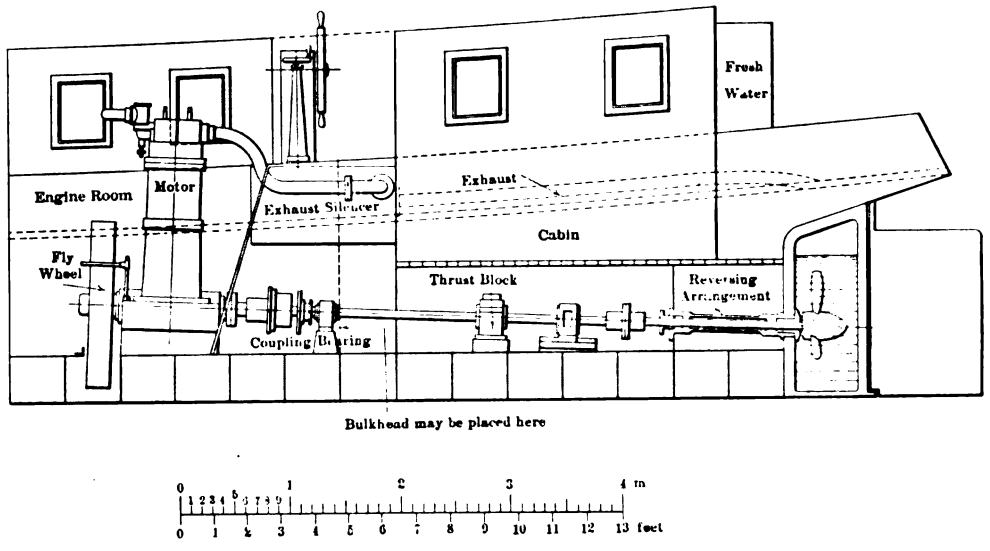

FIG. 1.—ENGINE-ROOM ARRANGEMENT FOR A 16-BRAKE-HORSEPOWER MARINE PRODUCER GAS PLANT.

DUTCH MARINE SUCTION-GAS PLANTS.—II.

BY F. MULLER VAN BRAKEL.

Suction-gas boats always have a separate engine room. Even in *Marenging*, where the installation is of the simplest, producer and motor are placed in a separate compartment. Oil engines can be placed under a casing, so a bulkhead may be dispensed with in very small boats, but suction-gas plants need space for the following items: First, bunker, producer and the firing; second, scrubber, water vessel, gas cleaner and exhaust silencer, and third, water filter, fresh-water tank, board with oil cans, etc. All this makes an engine room indispensable.

In the vessels described in this article the engine room is always placed aft. The room above the propeller tube is in the larger vessels (50 tons and upwards) taken by the cabin; the steering wheel; short shafting and an easy control of the engine room by the skipper at the wheel. It has the disadvantage, however, of making the ship liable to load by the head. As there is ample breadth in this part of the ship the engine room may be rather short, 9 feet being sufficient for installations up to 24 brake-horsepower and 10 feet for those up to 34 brake-horsepower.

The arrangement of the principal parts of the installation usually indicates the route taken by the coal and the gas. That is to say, from the aft corner port side to the forward corner port side is the bunker, next comes the producer with ash catcher; then through an overhead tube the gas is led to the scrubber in the forward starboard corner and to the last gas cleaner. From here through another overhead tube the gas passes to the motor, and then to the exhaust silencer in the aft corner starboard side.

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It will be seen that the length of the engine room is fixed by, first, the length of the motor; second, the room forward of it necessary for passing, and, third, the necessary space aft for couplings, etc. An oil engine would take at least the same length of engine room, and so it may be said that in freight boats of ample beam a producer installation does not require any more room than an oil engine.

The weights for a gas and for an oil installation of 24 brake-horsepower, and for a 34 and a 115 brake-horsepower gas installation, are as follows:

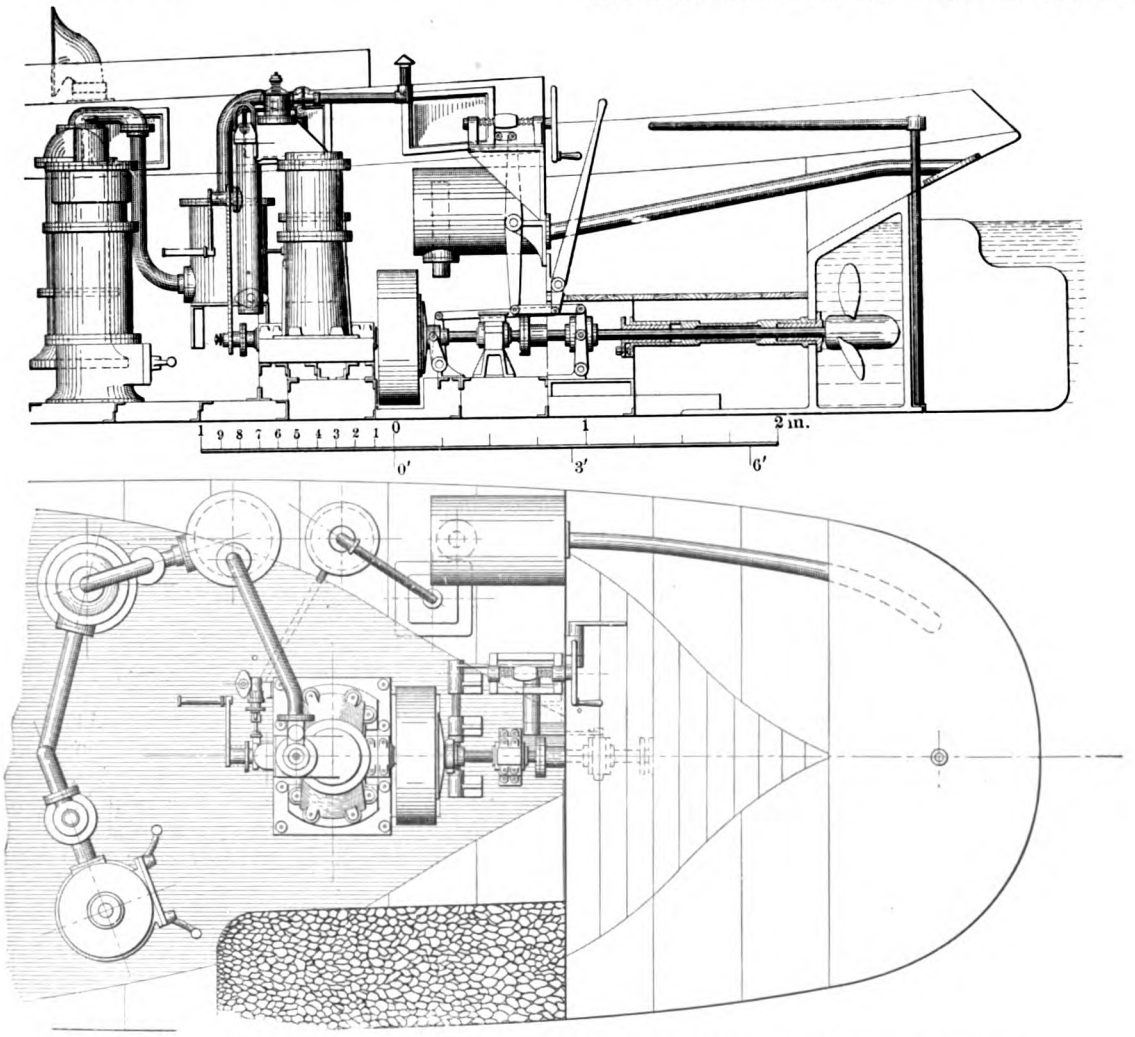

FIG. 2.—ENGINE-ROOM ARRANGEMENT FOR A 34-BRAKE-HORSEPOWER MARINE PRODUCER GAS PLANT.

TABLE 1.

	24 B. H. P. Oil.	24 B. H. P. Gas.	34 B. H. P. Gas.	115 B. H.P. Gas.
Motor complete, cwts.	46	55	59	225
Producer, ash catcher, scrubber, gas cleaner, water vessel; and for 115 B. H. P. motor: Small spiritas-starting motor	..	25	30	172
Engine seatings, coupling and reversing parts, silencer, sea valves, piping, hand pump, etc.	see motor weights	20	21	57
Thrust block and shaft, propeller shaft and tube, propeller	see motor weights	20	22	24
Complete installation, cwts.	46	120	132	478
Lubricating oil, etc.	4	4	4	8
Fuel for 100 hours	19	15	20	85
Complete installation and fuel	69	139	156	651
Complete steam installation and fuel for 115 B. H. P.	..	...	...	895

So the oil motor has about half the weight of the producer installation without fresh water. That means a difference of about 3½ tons, which is equal to 2.35 percent of the cargo weight in a 150-ton ship, or 3.5 percent in a 100-ton ship. It should be remembered, however, that the shipbuilder considers this extra weight near the stern a very good thing, as these ships with engine room aft have a tendency to load by the head.

ECONOMY.

A calculation of the yearly cost of running a producer-gas boat, an oil-motor driven ship and a steamship will show the advantages of one or the other type. Some of the amounts, such as those for repairs, depreciation, insurance, etc., are open to discussion. The amounts for coal and oil consumption are, however, exact, being taken from actual experience.

As it makes a great difference whether the ship is in service many or only a few hours every day, the calculation is made for three different cases. The first is for 1,100 sailing hours per year, the actual time of a 120-ton freight boat with a 31 brake-horsepower gas motor, which has been in regular service between Rotterdam and the north part of the Netherlands since 1904. Next, the time is taken as 1,800 hours per year, corresponding to 300 days of six hours each. And, lastly, the calculation is made for the somewhat exceptional case of 3,000 hours per year, to show where the advantage of gas over steam begins to tell.

For low powers the comparison is made with a 31 brake-horsepower Kromhout oil motor, built by D. Goedkoop, Jr., Amsterdam. The market price is $1,470 (£302). It consumes 0.82 pound of oil per brake-horsepower, costing $1.40 (5/10).

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For high powers the gas plant is compared to a steam installation, consisting of a vertical, compound, surface condensing engine, 10 inches by 20 inches by 13 inches, and a marine boiler of 645 square feet heating surface, producing steam at 155 pounds per square inch. Total cost of engine and boiler is $4,600 (£945), and the coal consumption 2.65 pounds per brake-horsepower, costing $0.48 (2/0).

The 31 brake-horsepower gas installation is an existing plant fitted by Messrs E. J. Smit & Son in the above-named 120-ton ship, 81 feet by 15 feet 3 inches by 5 feet 3 inches. The cost of the installation is $2,600 (£534). It consumes 1.1 pounds anthracite per brake-horsepower-hour, costing $0.32. The cost of the boat is $4,600 (£945).

The 115 brake-horsepower gas plant has been fitted by Messrs. E. J. Smit & Son in two 260-ton boats, 117 feet by 21 feet 6 inches, which cost $8,400 (£1,725). This gas installation costs $6,400 (£1,314), and consumes 0.85 pound of anthracite, costing $0.245 (1/0½) per brake-horsepower-hour.

TABLE II.

SHIP 81′ x 15′ 3″ x 5′ 3″. PRICE $4,600.

Depreciation 5 percent	$230
Rent 5 percent	230
Repairs ½ percent	23
Insurance 2½ percent	115
	$598

TABLE III.

31 H. P. GAS PLANT, PRICE $2.400. OIL MOTOR. PRICE $1,470.

	1,100 Hours Gas.	1,100 Hours Oil.	1,800 Hours Gas.	1,800 Hours Oil.
Depreciation—				
For gas, 1,100 hours 9½ percent. 1,800 hours 10½ percent	$228	$103	$251	$118
For oil, 1,100 hours, 7 percent; 1,800 hours, 8 percent				
Rent 5 percent	120	74	120	74
Repairs 1 percent	24	15	24	15
Insurance 2½ percent	60	37	60	37
Lubricating, cleaning, etc	50	30	80	45
	$482	$259	$535	$289
Fuel—				
Gas, 31 x 0.32 x 1-100 x hours	$110	$477	$178	$780
Oil, 31 x 1.4 x 1-100 x hours				

TABLE IV.

	1,100 HOURS.		1,800 HOURS.	
	Gas.	Oil.	Gas.	Oil.
Ship	$598	$598	$598	$598
Engine plant	482	259	535	289
Fuel	110	477	178	780
Total	$1,190	$1,334	$1,311	$1,667

Thus for 1,100 hours' sailing per year gas is about 13 percent cheaper, and for 1,800 hours about 28 percent cheaper.

TABLE V.

SHIP 117′ x 21′ 6″ x 7′ 10″. PRICE $8.400.

Depreciation 5 percent	$420
Rent 5 percent	420
Repairs ½ percent	42
Insurance 2½ percent	210
	$1,092

The high amounts for the depreciation of gas engines may, perhaps, seem unnecessary. It should be remembered, however, that the gas leaves a deposit in the cylinder that does *not* lubricate, as in the case of oil, or even steam engines. Though forced lubrication is used for the pistons, these still wear considerably, usually leak soon, and have to be renewed after some four or five years. Moreover, the deposit settles on the valve settings in the form of very small solid grains, which become very hard and make the valves leak. The frequent grinding wears the valves and settings seriously, and, when a hard grain gets between the valve and setting, pieces of the valve are occasionally broken off.

TABLE VI.

115 B. H. P. GAS PLANT, $6,400. 115 B. H. P. STEAM PLANT $4,600.

Depreciation— Gas 10 percent, steam 8½ percent. (mean values)	$640	$390
Rent 5 percent	320	230
Repairs, gas 2 percent; steam 1 percent	128	46
Insurance 2½ percent	160	115
Lubricating, cleaning, etc	85	55
Engineer	300	300
	$1,633	$1,136

FUEL.	1,100 Hours Gas.	1,100 Hours Steam.	1,800 Hours.	3,000 Hours.
Gas, 115 x 0.245 x hours	$310	...	$505	$840
Steam, 115 x 0.48 x hours	...	$610	990	1,660

TABLE VII.

	1,100 Hours.		1,800 Hours.		3,000 Hours.	
	Gas.	Steam.	Gas.	Steam.	Gas.	Steam.
Ship	$1,092	$1,092	$1,092	$1,092	$1,092	$1,092
Engine plant	1,633	1,136	1,633	1,136	1,633	1,136
Fuel	310	610	505	990	840	1,660
	$3,035	$2,838	$3,230	$3,218	$3,565	$3,888

The calculations show that for low powers gas is cheaper than oil, by amounts varying from 13 to 30 percent. But for higher powers, where steam would be used in the place of oil, steam is generally cheaper than gas. It should be remembered that the steam plant needs an engine room length of 30 feet against 18 feet 9 inches for the gas installation, which makes a difference of 780 cubic feet of cargo space in favor of gas. The steam plant weighs about 45 tons, against 32½ tons for the gas installation, giving 12½ tons more cargo for the gas-driven boat.

CONCLUSION.

The question may now be asked, when is it advisable to fit a marine producer-gas plant in the place of an oil or steam plant?

The present stage of development of the marine producer plant, so far as it has been carried in Holland, at once limits its use to powers under 100 brake-horsepower, as plants for higher power are at the present time too costly to compete against steam. If the demand for producer installations increases they will undoubtedly become cheaper, and, perhaps, become a serious rival for steam plants. As things stand now, however, it seems that the crude-oil motor promises better for the future than the gas motor. In Holland alone two modifications of the Diesel motor are being constructed with special regard to marine use.

For speed and pleasure launches producer plants are not as desirable as oil motors, because of their greater weight (of first importance in speed vessels), the greater space they occupy and the delay in starting caused by the firing. Moreover, as producer installations are only thought of where economy is desired there would be little inducement to adopt them here.

There remain commercial boats of low power, say 15 to 75 brake-horsepower. The above calculations show that in this case the producer gives a decided advantage over oil engines.

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This advantage, however, is only reached when—

1. The skipper is a good, trustworthy man, who takes pains to understand the installation and keeps it in very good condition.

2. The ship makes enough sailing hours every year to make the fuel-saving advantage perceptible.

3. The fuel prices are not too high.

4. The right sort of anthracite is obtainable in the port from which the vessel sails.

From point (2) it follows that a gas plant cannot be recommended as an auxiliary in sailing vessels.

THE MARINE STEAM ENGINE INDICATOR—IV.*

BY LIEUT. CHARLES S. ROOT, U. S. R. C. S.

PAPER DRUMS.

The accuracy of the indicator depends, to some extent, on the design of the paper drum and its mountings. Lightness is almost as important here as in the pencil actuating mechanism, and for the same reasons, *i. e.*, the effects of inertia. Where plain drums are fitted they are practically the same in all instruments, the principal differences being in the springs for turning the drums against the pull of the cord and the methods used for changing the spring tension. The drum consists of a hollow metal cylinder, fitted with fingers or clips for holding the card, the whole mounted on a base which revolves about a shaft secured to the body of the instrument. The axis of the shaft is parallel to the bore of the steam cylinder. In some cases the rotating springs are made of flat steel, mounted spirally after the manner of a clock spring; in other designs the springs are helical and made of round wire, encircling the shaft. Certain advantages are claimed for both forms by the various makers. The arrangement of the drum will be easily understood on inspection of the pictures of assembled instruments which will be shown hereafter.

DETENT MOTIONS.

In order that the paper "cards" may be changed on the drums without unhooking the cord, the drums are usually, but not always, fitted with a detent motion. This, in the majority of instruments, consists of a combination of ratchet teeth on the periphery of the drum base-ring, and a pawl on the indicator frame. When the pawl is thrown in the drum is caught and held stationary at the limit of its rotation against the pull of the spring. This fundamental idea is varied slightly in different instruments.

In an instrument made by the American Steam Gauge & Valve Manufacturing Company the paper drum is disengaged from its base-ring by the movement of a lever. The drum stops while the base continues its motion. The drum and base are again thrown into gear by a simple movement. With this mechanism five diagrams have been taken by a skillful operator in a little over one minute.

Many indicator manufacturers are now putting on the market instruments furnished with drums for taking continuous cards. These cards take a strip of paper from 6 to 12 feet long. The paper is fed along automatically or otherwise, so that it is possible to take from 75 to 150 diagrams on the strip. This arrangement, of course, adds something to the weight of the drum, but is exceedingly useful and almost a necessity where exhaustive tests are to be made of engines working under rapidly varying loads. Continuous diagrams, taken from a throttling rolling mill engine by a Schaeffer & Budenberg instrument, are shown in Fig. 32.

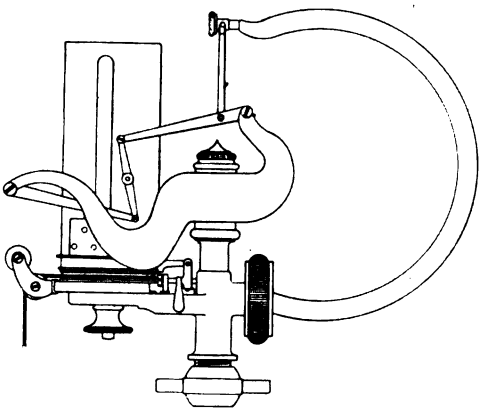

FIG. 33.

ELECTRICAL ATTACHMENTS.

To get reliable data from multiple-cylinder engines working under varying loads, such as in the case of a ship in a heavy sea, it is necessary that all indicator diagrams be taken simultaneously. In order that this may be accomplished by one operator, electro-magnets, or solenoids with suitable gear, are

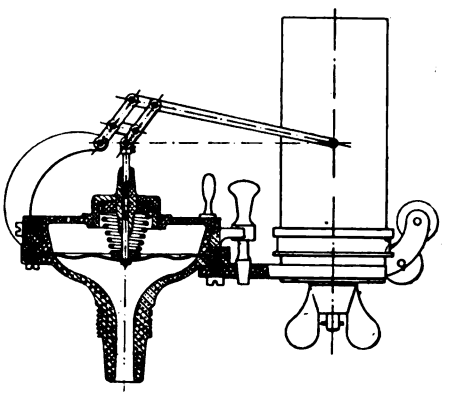

FIG. 34.

so fitted that the swivel heads of all the instruments are rotated by pressing a button. This brings all the pencils in contact at the same time. If indicators are attached to each end of each cylinder, a complete record can be made in a little over one revolution of the crank shaft. Devices operated by compressed air have also been made.

ASSEMBLED INSTRUMENTS.

Fig. 33 shows the Kenion indicator. This instrument is fitted with a peculiar spring and has no piston. The spring is similar to that of a steam gage tube, the partial circle formed by the spring expanding and contracting with the varying pressure. This movement is transmitted to and multiplied by the pencil motion, as shown in the sketch. It will be observed that the pencil mechanism is of the Watt or Richards type.

Fig. 34 is the indicator of Hädike. In this case the instru-

FIG. 32.

* Copyright, 1909, by Charles S. Root.

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ment is fitted with a flexible diaphragm in lieu of a piston. The parallel motion is a good illustration of the pantograph, as applied to the indicator pencil.

Fig. 35 illustrates one form of the Rosenkranz instrument. The parallel motion of this instrument is designed with a non-

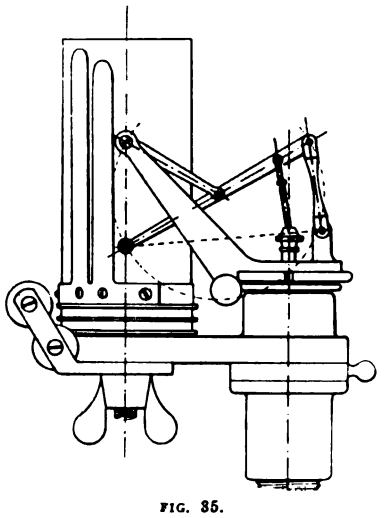

FIG. 35.

shortened front link, and with a back link so located that the versed sine of its arc of travel will be inclined. The action of a mechanism of this kind has already been discussed at some length and will be seen diagrammatically in Fig. 26.

(*To be continued.*)

NOTES ON THE OPERATION OF BABCOCK & WILCOX BOILERS.

In the design of the Babcock & Wilcox boiler seven prominent features are embodied: Straight tubes, expanded joints, forged steel, large furnace volume, adequate and practicable baffling, ability to clean exterior surfaces, accesibility to entire interior surfaces.

To the operating engineer the last two features are perhaps of the greatest importance, for cleanliness, more than any other one thing, is conducive to good steaming capacity, the saving of fuel and to prolonging the life of the boiler.

The baffling of the Babcock & Wilcox boiler directs the hot gases of combustion three times across the tubes before they escape to the up-take, thus insuring thorough distribution over the heating surface and consequent low final temperatures of the waste gases. Each of the three "passes" thus formed is provided with a series of dusting doors in the side casing, closed by patented air-tight shutters, giving access to the space between each pair of tubes. A steam lance, therefore, inserted successively through these openings effectually removes the soot from the exterior surface of the tubes. When performing the operation of blowing tubes always have full steam pressure on the lance, and move same in and out and from side to side to make the steam jet cover all the surface. Also have the boiler in operation if possible, the damper open and a good draft to take the soot away. If closed fire-room is installed, have a strong air pressure on. Place the lance first in the dust-door nearest the furnace, *i. e.*, the bottom opening in the "first pass," and "follow the gases" through the boiler, finishing at the opening nearest the up-take, *i. e.*, the top hole in the "third pass."

Nobody can lay down a fixed rule as to how often it is necessary to "blow tubes." The tubes are *accessible* for cleaning, however, and when the boiler is steaming and flame passing across the tubes, the dust and soot can be easily seen by inspection through the dust-doors. The old rule, "an ounce of prevention is worth a pound of cure," is a good one to follow, and it should be the object of the man in charge to utilize the ample means provided and keep *the boiler clean.*

The same remarks as to frequency of cleaning apply to the inside as well as to the outside of the tubes. Hand-holes are provided opposite each end of each tube. These are of the familiar elliptical type known to our forefathers, or a modification thereof. The plates are made of forged steel, and are faced to receive a thin gasket, as are also the seats on the inside surface of the forged steel headers against which the plates fit snugly. When making joints, use a seamless gasket made of asbestos, with wire insertion. A gasket cut from a strip and brought round and "pieced," will surely give trouble in the end, and could not even be considered "cheap at half the money." Do not soak gaskets in oil, as this rots them, but use plumbago on one side—the side next to the header. For convenience mix the plumbago with a little water. Wipe and clean the faced seats on the header and on the hand-hole plate carefully.

Owing to the fact that the tube is straight, the entire interior surface becomes visible to the observer on the removal of a hand-hole plate at each end. The frequency of cleaning depends on the condition of the water, amount of make-up feed and capacity at which the boiler is operated. A periodic examination is the only proper method to pursue.

The most satisfactory method of cleaning the interior surface of the tubes is to employ a turbine cleaner propelled by water power. A pressure of about 125 pounds per square inch is best, and fresh water is preferable, although salt water may be used in emergency, provided special care is exercised to wash out with fresh water and drain thoroughly afterward. When the scale is soft and light, hand scrapers may be used effectively.

The straight tubes and the location of the hand-hole plates provide the same facility for repairs as for internal cleaning; and the use of the expanded joint, familiar through long usage in shell boilers, greatly simplifies the question of repairs, which in nearly all instances may be made by the operating force without calling on the boiler maker. The same time-honored methods of cutting out tubes and nipples and re-rolling joints apply to the Babcock & Wilcox boilers as to shell boilers.

Should it be necessary to replace a tube, the new tube may be purchased in the open market, cut to length and without bending or threading or other work being performed on it, quickly installed in place by the use of the common expander. The tube should lap about ½ inch over the inside of the header seat. While it is a simple matter to plug a tube in cases of necessity, it takes so small an amount of extra time to replace a defective tube with a new one that this latter course is usually followed, and it may be noted that this sort of repair work makes the boiler as good as new—not patched.

Internal corrosion becomes a more and more acute malady as the steam pressure carried becomes higher, for the reason that with the consequent higher temperature of the contained water, the magnesium chloride, which is contained in all sea water, and which, unfortunately, too frequently gets into the feed system, becomes more and more corrosive. It is a matter of prime importance, therefore, to keep the condensers tight and to "freshen" up the boiler water by blowing down and adding good, fresh, make-up feed. A thin egg-shell scale, formed by feeding lime water to a new boiler, is a desirable thing, and a partial protection against corrosion; but do not be led astray by the idea of making a "salt scale"; it will not work at high pressures.

Another very corrosive element attacking the interior surface is air in the feed water; and while the internal feed arrangement adopted in Babcock & Wilcox boilers does very much to separate the air from the incoming feed, it is advisable to raise the filter box to insure a submerged suction to the

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feed pump and give the air a chance to escape, and also to install air chambers on the feed line, acting as reservoirs in which the air may be collected and held until discharged.

The well-known tests for salt and acidity should, of course, be applied to the boiler water, and an effort made to keep same fresh and neutral (or slightly alkaline) and free from air. If this is done and the zincs are kept clean and in substantial condition, the bugbear of corrosion may be reduced to a minimum.

The operating engineer who knows his business well enough to keep his boiler clean *inside and out* and free from corrosive influences is in a fair way to finding himself in charge of a model steam plant and needs little other advice. Possibly, however, a few words about water tending and firing may not be out of place. The Babcock & Wilcox boiler, of the design common in the merchant marine, contains about four times as much water as the express type of boiler of equal size, and is in consequence not subject to the rapid fluctuations in water level that characterize the latter; tending water being therefore a much simpler process. The aim should be to alter the checks *a little at a time,* thus maintaining a uniform feed, and it will be found that a very steady water line results. On the contrary, if the checks are opened wide one minute and closed tight the next, the water tender will soon be blaming everything but his own stupidity.

As to the matter of firing little need be said. The large combustion space of the Babcock & Wilcox boiler makes good results possible with very indifferent firing, providing the grates are covered, as the gases in passing back under the reverberatory roof have ample opportunity to mix and burn completely before getting in among the tubes of the boiler proper. Good firing will, of course, give proportionately good results, and a valuable rule is, "Light, Even and Often." The large, high furnace does offer one temptation to the firemen which should be guarded against: they are liable to want to pile it in and make a coal mine instead of a fire.

The level grate, with all fire-doors at the same firing height, is conducive to ease in handling the fires, and the main object of the fireman should be to keep the furnace *hot.* If the boiler is clean, it will absorb the heat effectually and make steam economically, and plenty of it. If the boiler is dirty, the reverse will be the case, and the object of this article will not have been fulfilled.

NOTES ON THE INGLIS BOILER.

The Inglis boiler is a modification of the ordinary Scotch boiler. It has three or four furnaces, as in the ordinary cylindrical type. It is fired in the same way, and as regards stoking and attention there is no difference between it and the ordinary type of boiler. The difference begins, however, immediately behind the furnace bridges. Instead of the gases passing from the fire grate direct through the tubes, the gases from the three furnaces all meet in one common combustion chamber of special construction at the back of the furnace bridges. The combined gases then pass through a second combustion chamber, in the form of a corrugated flue, to a third combustion chamber at the front of the boiler, where they enter the tubes, which extend from front to back end plates. This plan ensures that the cold or green gases from any one furnace, while being fired, get thoroughly mixed and ignited by meeting the hot gases from the other two furnaces, while the gases at the same time pass an extra or third time through the boiler. It further ensures that the gases, when they reach the tubes at the front of the boiler, are constantly of a uniform temperature, thus obviating entirely the principal cause of leaky tube ends; and since the tube plate is at the front of the boiler the formation of scoria thereon when forcing becomes an impossibility.

The third or front combustion chamber is formed by a removable brick-lined chamber, which further helps to maintain an equal temperature at the tube ends. Where heavy forcing and rapid steam raising are required, instead of a brick-lined chamber a water-jacketed cover is used, which acts as a circulator, the water-jacket being fed entirely from the very bottom of the boiler, and discharged into the steam space, the circulation also being assisted by four vertical watertubes in the back combustion chamber.

Another important difference in design is that the tubes are carried the whole length of the boiler. Of course, the tubes are longer than in the ordinary type, and, as a consequence of this, the heating surface is increased in the direction most capable of transmitting the heat to the water. Due to its greater facilities for circulation and to the more uniform temperature throughout the boiler, steam can be raised from cold water to a pressure of 180 pounds in eighty minutes without in any way damaging the boiler.

Aside from the fact that the boiler will stand a great deal more forcing in a closed stoke-hold without damage, the same principles that apply to the care and management of a Scotch boiler should be observed with the Inglis boiler.

HANDLING OF THE TAYLOR WATERTUBE BOILER.

The Taylor watertube boiler is a sectional boiler, having twenty-eight sections. Each section consists of thirty-three interchangeable elements, giving the boiler 924 short, vertical tubes for circulation and steam generation. The elements are joined at their ends by internal right and left nipples of forged steel, the ends thus forming headers. The construction is such that any element can be removed and replaced in two hours' time.

When placed in the boiler the upper and lower headers of each section all but touch the corresponding headers of the adjoining sections, thus forming what corresponds to a crown sheet above the fire, and closing the top of the flue passage. Near the back end a space is left in which there are no sections, the water-legs at the sides running to the height of the upper headers. This forms an efficient combustion chamber exactly similar in form to the combustion chamber of the Scotch marine boiler.

The fire burns back through the furnace, passes up into the combustion chamber, and then takes a horizontal path to the front of the boiler, coming in contact with the 924 tubes on its way. After passing through the nest of sections the heat rises through the up-take in front and then passes through the nest of feed-heating coils to the stack. The fact that the volatile gases have to pass back over the fire and then enter the combustion chamber is indicative of good combustion; and the long travel of the hot gases through the restricted flue area, with the ample amount of heating surface presented to them, meets the requirements of good heat absorption.

In firing the boiler no previous experience with pipe boilers is necessary, as the furnace, being in its nature practically the same as that of the Scotch boiler, is fired exactly as the Scotch would be. The green coal is fed into the front of the fire and later pushed back. This compels the gas to pass back over the glowing fire, and insures the best combustion. The two or three furnaces, as the case may be, should be fired alternately, as the combustion chamber is common to all of the furnaces, and the incandescent gases from the glowing fire will help complete the combustion of the gases from the freshly-fired one. Steam pockets, and the burning consequent from them are claimed impossible.

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The arrangement for handling the feed water in the Taylor boiler has been carefully worked out, with the idea that the best way to keep a boiler clean is to prevent any scale-forming matter from entering it. If the boiler is blown out according to the directions it will be impossible for scale to get into the tubes. The feed water after passing through the coils is fed into an impurity separator to remove any mud or other matter held in suspension. This consists of a 5-inch pipe with the ends capped and the lower part encased in the brick work around the fire front. The feed passes into the separator from the top, and is carried straight down to about its middle by an internal pipe. The feed water and the impurities are projected downward with a velocity nine times as great as is the flow of the water up in the separator to the outlet at the top. The sediment will therefore settle in the bottom of the separator, where it is protected from the heat, and where the water is therefore quiet. From the top of the separator the water is piped to the drum, and enters the drum at about the water-line, or is sprayed into the steam space. It then reaches a very high temperature, and any scale-forming matter held in solution is precipitated.

As the down-flows tap the drum several inches above the bottom, the sediment traps in the drum, and is removed by opening the blow-off, which is piped to the bottom of the drum. Should any be carried down the down-flow pipes it will settle in the mud-drums, and will be removed by the bottom blows, as there is but little circulation through the mud-drums or up the water-legs. It will be seen that the blow-off valves from the separator and from the drum are the most important, and they should be used as often as experience shows to be necessary. At intervals, depending on the use, the boiler should be given a thorough blowing out, which may be done by first blowing all the water from the drum through the drum-blow, and then blow down from the bottom blows until the water is several inches below the top headers. It will be seen that until the drum is empty there will be practically no circulation down the water-legs from the sections, for until it is so the water would come down the down-flows from the drum. The engineer should watch the discharge from the blowing at first, and should set his intervals and the amount blown by the amount of dirt that he sees discharged. Where steamers are on a daily run, about once in two weeks the boiler should be fed a solution of salsoda an hour or so before the end of the last trip, and this allowed to stand in the boiler all night. In the morning it should be drained off and the boiler rinsed out and then refilled.

Steam lances are supplied with the boiler, which blow five ways at the end, and with these the flue space can be kept perfectly clean, both fore and aft and between the tubes.

Any engineer who will give the boiler ordinarily good care can get the most excellent results from it, for it has a big, square section of furnace with an even height above the entire grate; the fire burns back to the combustion chamber, giving the very best possible combustion; the travel of the heat is through a long and properly proportioned path, with no chance of short cutting and with abundant heating surface surrounding it; the steam leaves the heating surface and rises immediately to the steam space, leaving the heating surface at all times covered with water and preserving its heat-absorbing capacity, and the rapid circulation increases the heat-absorbing capacity of the tube surface.

According to the *Engineering Record*, suction gas tugboats have been tried on the Rhine, towing cargoes of 350 tons in two barges. The boats are said to have proved successful and reliable, the cost of fuel being from 50 to 70 percent less than that of steam tugs. Lignite, mined in the neighboring provinces at very small cost, is used for fuel.

INSTRUCTIONS FOR OPERATING ALMY BOILERS.

The care that should be given an Almy boiler differs little from that required by boilers of any other type. It is hardly necessary to say that grease, salt and mud must be kept out of the boiler, and the heating surface free from soot and ashes, if repairs are to be obviated and the greatest efficiency obtained.

There is no reasonable excuse for allowing a boiler to suffer from grease. In these days of high pressure, the larger percentage of engines are fitted with piston valves which require little or no oil. Auxiliaries, especially pumps, need some cylinder lubrication, but if purely mineral oil or lubricant, or at least that which contains absolutely no animal fats, are used, a carefully looked after filter box will guard the boiler from any harm. With slide-valve engines more than ordinary care should be used in selecting cylinder lubricant to avoid animal grease,

As this boiler contains only about 10 percent as much water as a Scotch boiler of the same power, more care should be exercised and frequent blowing off resorted to if it becomes necessary to use salt water, as the density increases much faster than with the "tank" boiler. A condition that brings trouble to the engineer and repair bills to the owner is often brought about by a small amount (almost imperceptible) of salt, combined with animal grease, gradually but constantly fed into the boiler.

In order to obtain the best results freeing the boiler from sediment through the blow-off pipe, blowing should be done in the morning as soon as there is pressure enough to operate the blow-off, say 5 to 10 pounds. If the boiler has been laying quiet during the night, most of the foreign matter will have settled, and the blowing at this time will accomplish more than fifty times as much as when the boiler is in full operation.

There are many occasions when from scale or other internal troubles it becomes necessary to "doctor" a boiler, but it is far from wise to dose it with compounds of unknown ingredients, especially without knowing the origin or component parts of the scale.

The accessibility and ease with which repairs can be made to this boiler are worthy of more than a passing glance. As the sections are connected at either end with a union and asbestos gasket, it is an easy matter to remove a defective section and install a new one. Any of the side sections may be disconnected and taken out through the ash-pit doors. The fore-and-aft sections have to be taken out at the back of the boiler, unless the side sections on one side of the fire-box are removed, allowing the fore-and-aft sections to come out through the ash-pit door. It is not advisable to go to the trouble to replace one fore-and-aft section; better stop it off with an ⅛-inch metal disc in the top and bottom union, and leave it in place. The vertical pipes will, of course, burn away after a while, but it takes some time. After a number have been thus treated it is well to lay off and replace them all at once.

To remove and replace a section, first remove five or six grate-bars; next start the bottom union nut with a round-nose calking tool, and hammer and back it off. Let a man enter the boiler above the sections through the back door, and unscrew the top union nut in the same manner as the bottom one. Now pull the bottom end of the section into the furnace, and the section may be dropped into the ash-pit.

Clean off the face of the flanged nipples and put the new section in place; spring down the top (if necessary) and insert the gasket (asbestos about one-sixteenth inch thick should be used, not rubber); force the section up against the packing; screw on the union nut, using an 18-inch Stillson wrench or small chain tongs, and drive up solid with a round-

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nose calking tool and hammer. Now do the same with the bottom end. Be sure to have the section end against the packing when screwing the nut on, else the nut may catch the packing and harm it. To haul a fire, blow down, stop off a section or remove and replace a side section and get steam again occupies from one and one-quarter to two hours' time.

Now a word about firing. You "Scotch boiler fellows" must forget all about Scotch boilers and become fearful that too much coal at a time will put the fires out, for it is about the same thing with the watertube boiler, so the firing must be done light and often. Try to keep a fairly level fire, with the sides and ends rather higher than the middle and the corners well filled up. There is a great opportunity to lose steam with lean corners. Do not let all the firemen fire at once. One shovel in a fire room is an excellent precaution. With soft coal, break up the fire with a hook. If you use the bar, do not turn the fire over, just lift it. If you have rolling bars, roll them often and leave them on a new square each time, and they will keep straight much longer. If you show a flame at the top of the stack "crack" your furnace doors. This will some times stop it even with very gasey coal.

Do not try to keep steam down by closing the damper when lying still, but open it and the cleaning doors in front, and let the air draw through; cooling down this way will not cause leaks in this boiler. Do not "pull your engine wide open" with a green or poor fire. If you do you will pull the water over, There is very little storage for energy in this boiler and you must depend on the fire for it. If you can anticipate your leaving time a few minutes, have your fires bright, take care of your surplus steam with the "bleeder," then when you get "full speed ahead" close your fire doors and "bleeder" and the boiler will respond.

Keep the heating surface clean, and you will save both labor and fuel. Be sure to have the steam jet in the stack in full operation while blowing off tubes, and the accumulation will all be taken out through the stack.

Now a few words about laying up. The time spent in thoroughly cleaning the heating surface for a six months' lay up should not be questioned by the owner, even though a man puts in six or seven days on a boiler, as ashes and soot collect moisture, and that is more or less corrosive in nature, which will deteriorate the metal much faster than actually operating the boiler.

After blowing off it is a good idea to thoroughly dry out the boiler with a light fire of wood. Then the heating surface should be scraped and dusted as completely as possible from top to bottom. All iron in ash-pans should be painted with iron oxide or red lead paint. Even painting the heating surface as far as possible is good policy. This or spraying with crude oil is desirable if no heat is to be kept in the fire-room during the winter.

SPECIAL POINTS TO BE OBSERVED IN THE UPKEEP OF NICLAUSSE BOILERS.

One of the most important features of the Niclausse boiler is the arrangement of tubes. A form of joint is used which enables the tube to be taken down and replaced from the front of the boiler. The outside generating tube, which is put in first, fits into the back and front of the header by means of two long cone joints. The whole is held in position by means of a dog, which bears upon the center portion of the lugs of two adjacent tubes. The external tube is slightly thickened at the end where it joins the lantern, and is turned to a slight taper, fitting into a tapered hole in the rear plate of the header. The middle portion of the lantern, which is cylindrical and of slightly larger diameter, fits into the dividing plate or diaphragm of the header, and the extreme end, which is of larger diameter still, is coned, and fits a coned hole in the front plate of the header. The inner tube is also provided with a lantern of somewhat different form. The bearing points are at the diaphragm of the header and the outer portion of external lantern. The entire arrangement of tubes can, therefore, be taken out from the front of the boiler.

In general, Niclausse boilers afford good facilities for inspection and up-keep. It is not sufficient merely to empty the tubes from the front ends. They must be taken out and completely emptied unless the whole boiler, when laid up, is completely filled with fresh water and lime. Frequent inspections are necessary, as is the case in any boiler, to see that no deposits are occurring to stop the circulation. The taking down and replacing of the tubes must be done with care, so as not to injure the fine threads. The brick work in front of the boilers must also be carefully maintained.

Stoking with this type of boiler is, of course, very important, and must be regular and methodical. The same considerations apply here, however, as apply to stoking in any similar type of watertube boiler. There is one difficulty which should be guarded against very carefully, and that is any obstructions occurring between the inner and outer tubes which would tend to stop the circulation and cause overheating with possible rupture.

A special form of tube cleaner enables the tubes to be thoroughly cleaned without taking down the side doors. This can be done at little trouble, and therefore is likely to be done frequently, thus maintaining the efficiency of the heating surface. Cleaning is effected by fitting a hollow sleeve in place of a lantern here and there over the front of the boiler, through which the steam cleaning lance can be passed. It also enables the lance to be made of fairly large diameter, permitting a sufficient quantity of steam to blow through, not only to clean the tubes, but also to leave their surfaces practically dry. The use of the sleeve means the suppression of a few tubes and a consequent slight reduction in the quantity of heating surface, but compensation for this is found in greater cleanliness and consequent efficiency of the heating surface.

REGARDING THE OPERATION OF SEABURY WATERTUBE BOILERS.

The Seabury watertube boiler comes in the class of small tube boilers with expanded tubes. It consists of a steam drum and two water drums, each water drum being connected to the steam drum by a series of seamless drawn-steel tubes, bent in such a way as to allow for their expansion. The steam drum is large, providing a large surface of water to evaporate from, an essential feature in the generation of dry steam, especially when forced under 5 inches of water pressure, thus burning coal up to 100 pounds per square foot of grate surface with a corresponding high evaporation. Many Seabury boilers for yacht and torpedo boat work, where forcing is carried to the limit, are built with steam domes, from which the dry pipe is always able to draw dry steam.

Over the top of the nest of tubes is a heater, consisting of steel pipes running lengthwise of the boiler, connected at the ends with return bends, making a continuous path for the feed water which enters at one end and passes through the whole length of the heater, then entering the drum through a check valve. No baffle of brick or any other foreign material is used, the baffling being accomplished by the arrangement of the tubes.

Wrought iron grate-bars of square section extend through the boiler front for the purpose of shaking. By means of this shaking grate a hard-coal fire can be kept clean and in good condition for a long period. A hard-coal fire cannot be sliced and worked the same as when soft coal is used, without ruin-

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ing the fire; the shaking grate therefore offers the simplest and most effective method for marine work.

Cleaning doors in both ends of the casing, in way of nests of tubes, give access for cleaning accumulations of dirt from tubes and heater by means of a steam jet.

The main requirements for efficient working are: to keep the tubes and heater clean by frequent application of the steam jet, to keep the interior of the boiler free from oil by blowing down frequently, and by use of the surface blow, and, finally, to have the firemen trained to carry the proper kind of fire. It is also important that the water should not be carried much higher than the center of the drum.

The Seabury boiler is so simple that there are but few points about its handling which would be of help to the average engineer, other than the knowledge necessary to run any watertube boiler. Common to all watertube boilers of the small-tube variety, steam may be raised as quickly as a fire can be got on the grates. The water should be carried at about half a glass, at which level the upper row of tubes is submerged. Care should be taken to prevent the formation of steam in the heater. This is easily done by keeping the feed pump running (even though water is high enough in the glass) until the water is seen to rise perceptibly. This insures the heater being full of water all the time, and prevents the formation of steam in a portion of it, thus driving the water out into the drum and keeping up a false level in the glass. In short, never stop the pump except on a rising glass. Boilers should be kept clean, both internally and externally, by the frequent use of bottom and surface blows, and by the use of steam hose through the cleaning doors provided. The firing has to be varied to suit the kind of fuel and forced or natural draft, conditions understood by the average fireman, and not in any way peculiar to Seabury boilers. In laying up, it is always important to get all the water out; to do this the feed check between heater and drum should have its valve removed, and then after the bonnet has been replaced all the water in drum and heater can be blown overboard.

Annual Meeting of Naval Architects' Society.

The seventeenth general meeting of the Society of Naval Architects and Marine Engineers will be held in Assembly Room No. 1, Engineering Societies building, Thursday and Friday, Nov. 18 and 19, 1909, and will begin at 10 A. M. each day. The society's rooms will be open for the use of all members and the usual conveniences provided.

There will be a banquet at Delmonico's at 7.00 P. M., Friday, Nov. 19, to which all members and their guests are cordially invited; tickets are $5.00 each.

The Council will meet at 3.00 P. M., Wednesday, Nov. 17. Proposals for membership should be mailed so as to reach the secretary on or before Nov. 17.

The advance programme of the meetings is as follows:

THURSDAY, NOV. 18.

1. The Influence of Length of Parallel Middle Body upon Resistance. By Naval Constructor D. W. Taylor, U. S. N., vice-president.
2. The Influence of the Position of the 'Midship Section on the Resistance of Some Types of Vessels. By Prof. H. C. Sadler, member of Council.
3. Some Plane Ship-Shaped Stream Forms. By Assistant Naval Constructor William McEntee, U. S. N., member.
4. A System of Propulsion for Naval Vessels. By W. L. R. Emmet.
5. The Producer-Gas Boat *Marenging*. By H. L. Aldrich, member of Council.
6. Building and Equipping the Non-Magnetic Auxiliary Yacht *Carnegie*, with Producer-Gas Propelling Equipment. By Wallace Downey, associate member.
7. The Design of Submarines. By Marley F. Hay, member.

FRIDAY, NOV. 19.

8. The Foreign Trade Merchant Marine of the United States. Can it be Revived? By George W. Dickie, member of Council.
9. Material Handling Arrangements for Vessels on the Great Lakes.
10. Proposed New Rules for the Construction and Classification of Steel Vessels. By James Donald, member.
11. Rivets in Tension. By Robert Curr, member.
12. The Strength of Watertight Bulkheads. By Prof. Wm. Hovgaard, member.
13. Cruising Motor Boats.

THE FASTEST VESSELS IN THE UNITED STATES NAVY.

What have proved to be the two fastest vessels in the United States navy have just been completed by the Bath Iron Works, Ltd., Bath, Me. They are the *Flusser* and *Reid*, two of the five destroyers, bids for which were opened in September, 1907, and contracts for which were awarded as follows: The *Flusser* and *Reid* to the Bath Iron Works; the *Smith* and *Lamson* to the William Cramp & Sons Ship & Engine Building Company, Philadelphia, Pa., and the *Preston* to the New York Shipbuilding Company, Camden, N. J. The contract for the *Flusser* and *Reid* specified that the vessels were to be delivered to the commandant of the navy yard, Boston, Mass., not later than September 28, 1909.

The hulls of the *Flusser* and *Reid*, designed by the Bureau of Construction and Repair, are of the following dimensions:

Length between perpendiculars	289 ft.	
Length over all	293 ft.	10½ ins.
Breadth molded at trial waterline	25 ft.	11½ ins.
Breadth molded extreme	26 ft.	4½ ins.
Breadth extreme over guards	27 ft.	
Trial displacement	700 tons	
Trial draft at this displacement	8½ ft.	

As will be seen by the above dimensions the lines are very fine.

The contract weight allowed for the machinery was 255 tons, provision being made for the assessment of a penalty in case this weight was exceeded. The machinery, however, complete, with water and spares carried on board, weighed only 228 tons, so that the trial displacement was reduced by this saving of 27 tons, less an overweight of 4 tons, or a net weight saved of 23 tons. The trial displacement therefore was fixed at 677 tons, but on all of the trials of these vessels the displacement was slightly greater than this.

The machinery is of the contractor's design, and consists of five Parsons marine steam turbines on three shafts; the main high-pressure being on the center shaft; the starboard low-pressure and intermediate-pressure cruising turbines, together with the starboard backing turbine being on the starboard shaft, and the port low-pressure and backing turbine and the high-pressure cruising turbine on the port shaft. The steam piping is so arranged that any of these turbines can be run as the initial turbine. All of the turbines are in one compartment, and they were designed to develop 10,000 shaft-horsepower, at 800 revolutions per minute, with about 240 pounds of steam in the high-pressure steam chest.

The two condensers were built up of plate with composition tube sheets, each containing 4,000 square feet of cooling sur-

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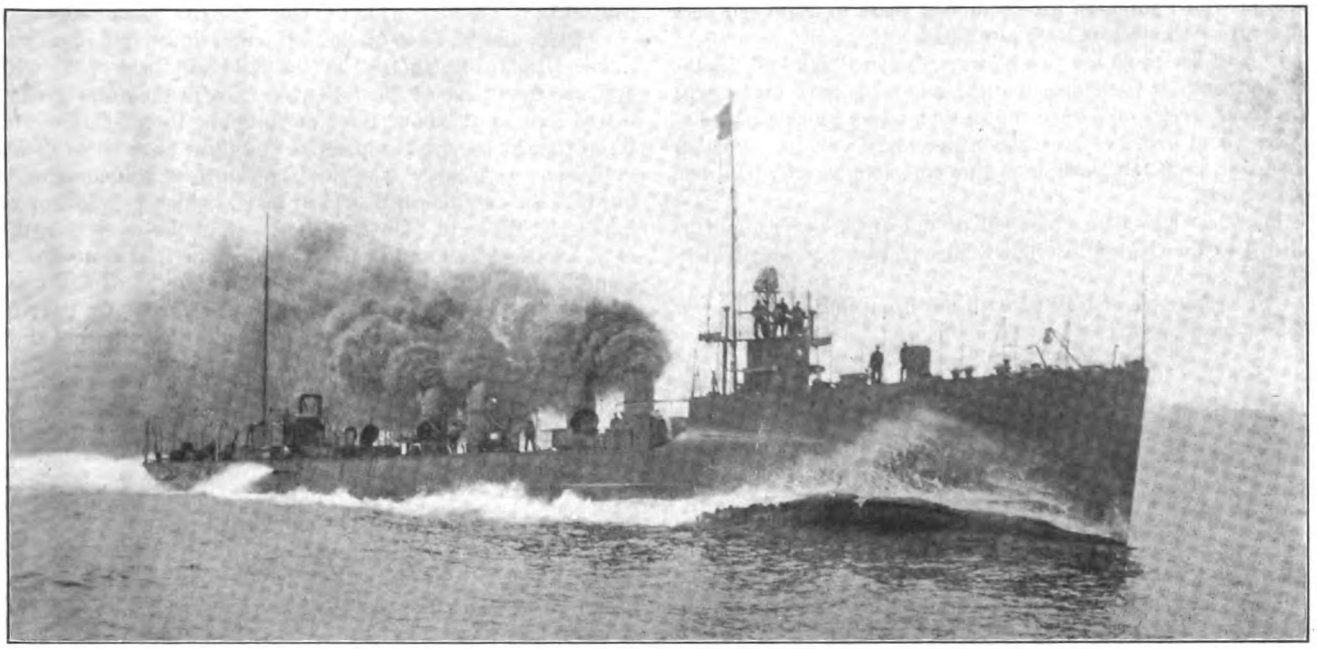
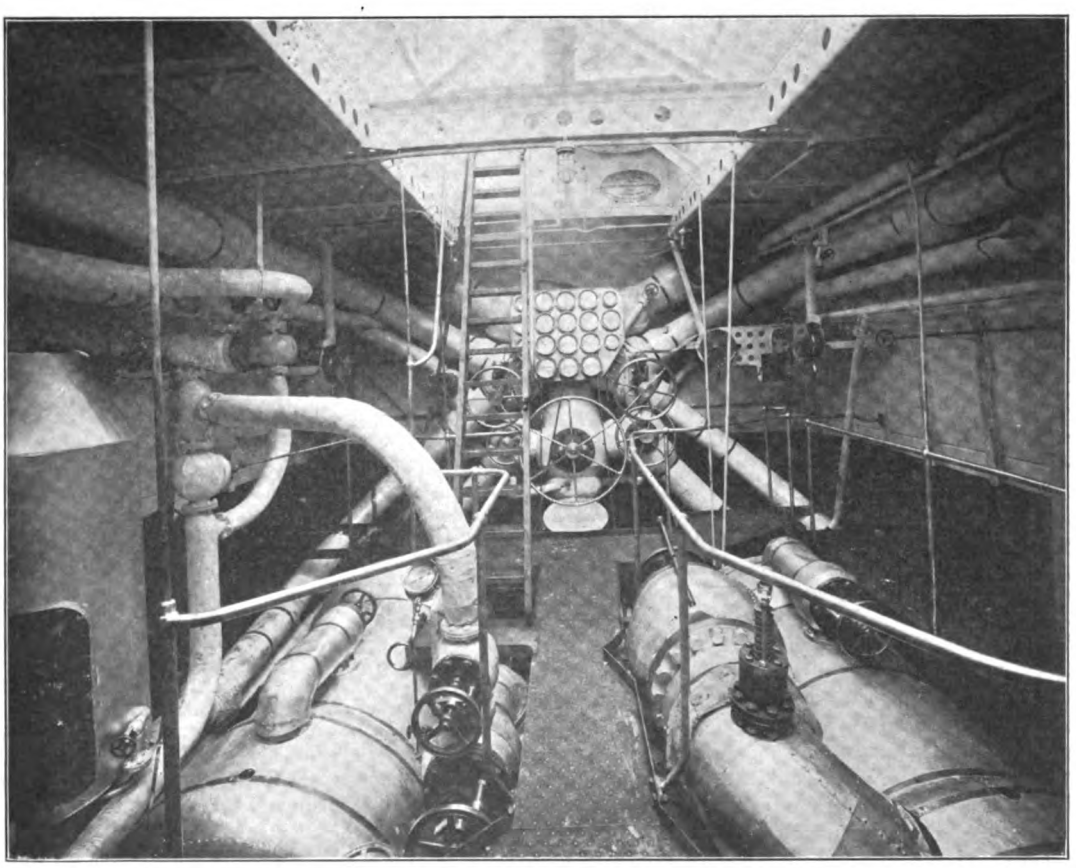


THE NEW UNITED STATES DESTROYER FLUSSER STEAMING AT 33.7 KNOTS.

face, measured on the outside of the tubes. The tubes are curved and expanded into the tube sheets, no packing being used. The circulating water is provided by scoops, this method proving extremely satisfactory. Small circulating pumps, however, are provided for use when the vessel is still in the water, or when getting under way. There are the usual air pumps, feed pumps, fire and bilge pumps, oil pumps, etc. An evaporating distilling apparatus was also provided, with the necessary pumps.

The boilers are four in number, of the Normand return-flame type, and are placed in two water-tight compartments, there being a smoke-pipe for each of the four boilers. The total grate surface is 346.67 square feet, and the total heating surface 16,177 square feet. Normand feed-water heaters are



INTERIOR OF ENGINE ROOM LOOKING FORWARD. STARBOARD I. P. AND PORT H. P. TURBINES IN FOREGROUND.

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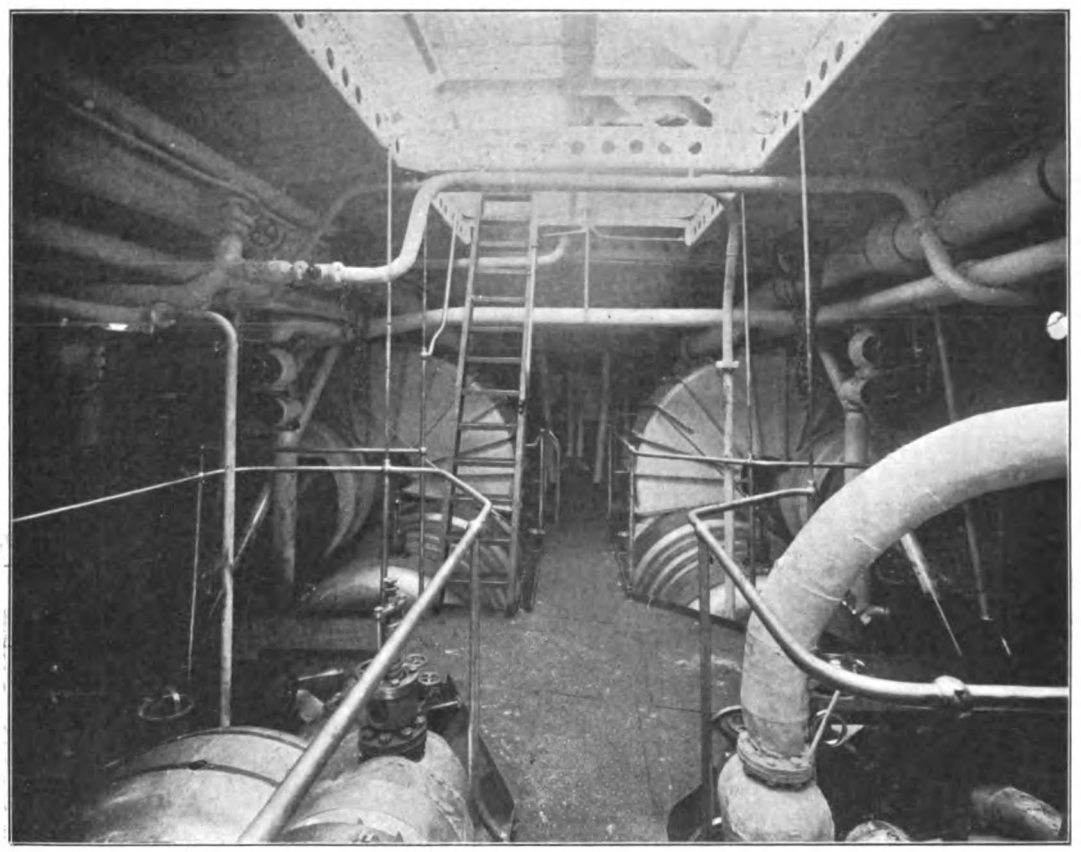
also provided for each fire-room, and these have proved very efficient. Ash ejectors were also fitted.

In each fire-room are two blowers, designed and built by the contractors. It is claimed that these blowers have given most excellent service, and have shown themselves capable of delivering air at 9 inches pressure in necessary volume. Further than this, each fan, with its engine complete, weighs less than 900 pounds.

The electrical plant consisted of one turbo-generator, furnished by the General Electric Company, together with switchboard, searchlight, etc.

The vessel was also fitted with the usual means of interior communication, telephones, bells, etc.



INTERIOR OF ENGINE ROOM LOOKING AFT.

The contract specified that the vessels should be given standardization trials of not less than twenty runs over the mile, a four-hour full speed trial, on which the speed shown should average not less than 28 knots, a twelve-hour trial at 24 knots, and a twenty-four trial at 16 knots, and that the water consumption per shaft horsepower should not exceed 25.2 pounds on the 16-knot trial, 16.5 pounds on the 24-knot trial, and 15.5 pounds on the full-speed trial. All of these guarantees were met with a comfortable margin.

The standardization trial of the *Flusser* was held on September 21, over the Government mile at Rockland, Me., and was to consist of the following runs, in the order given: Three runs at 12 knots, three runs at 16 knots, three runs at 24 knots, three runs at 26 knots, five runs at top speed, and three runs at 28 knots. After entering the mile for the nineteenth run, however, fog shut in, and the balance of the runs were abandoned. The data, however, was sufficient to construct the speed curve. The next morning, Sept. 22, the *Flusser* left Rockland for her twenty-four-hour trial at 16 knots, ending this trial the next morning at the works of the contractors. On Sept. 24 the twelve-hour trial at 24 knots was completed, and on Sept. 26 the full power four-hour run.

The standardization trial of the Reid was held on Oct. 6, and was to consist of the following runs, in the order given: Three runs at 12 knots, three at 16 knots, three at 24 knots, three at 30 knots, five at top speed, and three at 28 knots. Two extra runs were made at 28 knots, owing to a misunderstanding that the counters had broken down, which proved not to have been the case. On the afternoon of the same day the *Reid* left Rockland on her twenty-four-hour trial at 16 knots, completing this trial and arriving at the works of the contractors the next afternoon.. The next day, Oct. 8, the twelve-hour trial at 24 knots was completed, and the following day, or the 9th, the four-hour full-speed trial was completed.

The following table gives the results of these trials:

	Flusser.	*Reid.*
Speed, fastest mile	33.67kts.	34.55kts.
Mean speed five high runs	32.67	33.75
Maximum shaft horsepower developed	14,400	15,140
Mean speed, four hours	30.41	31.85
Speed, best 15 min. during four-hour run	30.85	32.25
Revolutions necessary for 28 knots	706	700
Revolutions maintained four hours	801	846
Shaft horsepower during 4 hour trial, average	11,541	12,564
Indicated horsepower of auxiliaries during 4 hour trial, average	301	310
Total horsepower during 4 hour trial, average	11,842	12,874

The horsepower per ton of machinery, including spares and water, floors, gratings, handrails, ladders, etc., works out at 66, a figure which, so far as known, is a record.

No limit was placed upon air pressures on the standardization trials; the *Flusser*, carrying a maximum of 8 inches on

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the highest run, and the *Reid* 5 inches in one fire-room and 6½ in the other. The contract provided, however, that an average of 5 inches should not be exceeded on the four-hour trials,and the 5-inch average was maintained but not exceeded on both vessels.

Both the *Flusser* and the *Reid* were equipped with Parsons vacuum augmentors, which performed very satisfactorily, as vacuums were maintained on both vessels at all speeds of between 28½ and 29 9/10 inches. These vessels are the fastest ever built in the United States, the fastest mile covered by the *Reid* being at the rate of 39.78 statute miles per hour. The builders are to be congratulated on having turned out such successful boats.

THE OPERATION AND CARE OF MOSHER BOILERS.

TO PREPARE A NEW BOILER FOR STEAMING.

Before steaming up a new boiler after it has been installed and has passed a satisfactory hydrostatic test, the manhole plates in the steam and water drums, as well as the cleaning doors in the casing, should be removed when the interior of the drums, casing and furnace should be carefully inspected to see that no tools, waste or other foreign matter has been forgotten and left about the boiler. Then the tubes should be thoroughly cleaned and washed out, the dirt being easily removed through the hand-holes in the water drums. All the interior fittings, such as dry pipe, feed distributing pipes, zincs and their baskets, scum pans, etc., should be carefully examined to see that they have not been disconnected but are secure in their proper places. Examine carefully all valves and fittings, particularly the safety valves, to make sure they are in proper working order. The seats and covers of manholes should be carefully examined, to insure alinement and freedom from foreign matter, in order to obtain a perfectly steam-tight joint.

From 2 to 3 pounds of salsoda, dissolved in water, should be put in the boiler for each 1,000 feet of heating surface, and then the boiler filled until the water shows a little more than half a glass when under steam. Note that the water shows a corresponding height by the gage cocks and gage glass.

A light fire may now be started, and the boiler boiled out for one or two hours under 100 pounds pressure. This will effectually cut off or dissolve all oils, grease, tallow and other foreign matter, after which the boiler should be blown down 3 or 4 inches by the surface blow, then filled to the previous height, and this operation repeated three or four times a few minutes apart. Finally, allow the boiler to cool down and the water to run out, or blow out, under low-pressure through the bottom blow-off valves. The object of cooling the boiler down before blowing it down is to prevent the baking on the surfaces of any sediment or other impurities by the heating of the boiler.

The boiler can now be refilled with fresh water till the glass shows about one-quarter full, which, when under steam, will show about half-full. Before lighting the fire see that the air cock is open, or other means for escape of the air from the interior of the boiler is provided.

GETTING UP STEAM.

Spread a light cover of coal over the whole grate, then build a wood fire on top of the coal and gradually add coal as the fuel becomes ignited until the required depth of fire is obtained, or if another boiler in the same fire-room is under steam a few shovels full of burning coal from it may be placed near the front of the furnace; the fire will then gradually creep back and may soon be spread over the whole grate. The ash-pan door should be wide open and the fire-doors slightly open when first starting the fire.

Under ordinary conditions the fire should be started about three-quarters of an hour before steaming, in order to enable a good bed of coal to become ignited. In cases of emergency, however, from fifteen to thirty minutes will be sufficient to raise full steam pressure if means are provided for forcing the fires.

The firing should be done regularly at frequent intervals, the fires being kept as thin as possible without forming air holes. Where a number of boilers are under steam, each having several fire-doors, it is preferable to fire the doors beginning on the right-hand side in succession on each boiler instead of firing all the doors of one boiler before proceeding to the next one.

Broadly speaking, firing may be divided into two classes—coking and sprinkling. The former is preferable for natural draft, and, if properly handled with the proper supply and distribution of air, should be practically smokeless. The air supply should be only slightly in excess of the theoretical amount required for complete combustion. The fuel should be fed at the front end of the furnace and gradually worked back by the firing tools. The coking action takes place when the fuel is banked at the front of the furnace subject to the radiant heat of the more active portion of the grate. The combustion of the gases is greatly assisted by the admission of pre-heated air, preferably delivered in the form of jets at high velocity into the furnace above the fuel. Means to supply air jets and means for pre-heating the air are always provided in Mosher boilers.

All parts of the fire over which the gases from the fresh fuel pass should be kept at a sufficiently high temperature to ignite them. At the same time the supply of air for the fuel should be delivered in the form of numerous jets at high velocity, in order to thoroughly mix the air with the gases and insure complete combustion.

The fires should be of even thickness and as thin as possible. Generally, they should not exceed 5 or 6 inches unless there is a very strong draft.

FORCED DRAFT.

For boilers running under forced draft, particularly where there is a fluctuating demand for steam, the sprinkling method of firing is more suitable. The fuel in this case is evenly spread over the entire surface of the fire in each of the charges, care being taken to fill up any holes.

The average depth of the fire with a draft equal to a column of water 3 or 4 inches high should not be over 8 or 9 inches. Naturally, the heavier the draft the heavier the fire, but it should be borne in mind that the thinner the fire the better the combustion, provided thin places and holes can positively be avoided.

If air is admitted into the ash-pan entirely through doors in the front end under heavy forced draft, its momentum carries it to the back end of the furnace with such force as to cause a very much greater amount of coal to be burned at the end of the grate, unless the fire is carried much thicker at that point. In some cases, the fire should be carried as much as 50 percent thicker at that end than at the end of the furnace nearest the door in order to realize an equal rate of combustion for all parts of the grate.

If the maximum steaming capacity is required, it can be more easily attained by keeping the largest possible area of the fire in an incandescent condition at the greatest possible heat. An extended front greatly assists in this case, as it enables practically all that portion of the fire under the tubes to be kept in an incandescent state, the radiant heat from which, it is admitted by eminent authorities, does fully 50 percent of the work.

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SLICING FIRES.

No very definite instructions can be given for slicing fires, since this depends on so many variable factors. It is sufficient to say that it is necessary to slice the fires frequently enough to thoroughly break up the coking of the coal and distribute it so as to fill up any holes as well as to raise off from the grate any clinkers that coke on and prevent air from getting through. Of course, a dead place in the fire indicates that slicing is necessary.

CLEANING FIRES.

In cleaning fires when under way it is essential that the amount of grate surface put out of effective use at one time be as small as possible. Where there are a number of boilers it is best to burn down the fire in the boiler to be cleaned at a time when the fires in the other boilers are at their maximum heat. It is also advisable to clean only that portion of the fire opposite one door at a time, pushing the unconsumed portion of the fire on the adjacent side of the grate. Thoroughly remove all ashes and clinkers, after which the fire may be hoed back and spread evenly over the grates and covered with a thin layer of coal. Some interval, during which another boiler may be cleaned, should elapse before cleaning the next portion of the fire in the first boiler.

BANKING FIRES.

The fires should first be cleaned, the feed pump being allowed to run until the gage shows about three-quarters full. After cleaning, the fires should be pushed back and banked at the back end of the furnace, the ash-pan doors being closed and the fire-doors completely or nearly closed, as required.

If it is desired to keep the steam pressure up for a few hours, and the fire in such a condition that it can be spread and brought to its maximum capacity in a few minutes by the aid of forced draft, it is best to cover the banked fire with only fresh coal; whereas, if the fire is to be kept over night with only a low-pressure of steam, it is best to cover the banked fire with wet ashes and partly open the dampers in the stack, or open the doors into the up-take.

CLEANING BOILERS.

The best way to keep a boiler clean is to thoroughly purify the water from all scale-forming matter or other impurities before it enters the boiler. If this is not practical, and the interior of the boiler becomes coated with scale or other impurities, easy access can be had to all interior parts of the Mosher boiler. As many as fifty tubes may be examined, cleaned or replaced through each of the hand-holes in the upper portion of the steam drum. If there is an excessive amount of impurities in the boiler, the steam and water drums may be entered through manholes, and the interior of all the tubes conveniently cleaned by any of the ordinary tools.

To keep the exterior of the boiler free from soot and dust, the Mosher boiler is provided with cleaning doors for use when the boilers are not under steam, in addition to three soot-blowing pipes, permanently built in the boiler casing away from the heat, so that they will not be burned out. These pipes, which are of substantial size, run the whole length of the casing, and are perforated with four rows of holes, so arranged as to cause jets of steam to be blown over practically all portions of the boiler tubes. These pipes take steam direct from the boiler and are controlled by a single valve. By opening this valve two or three times a day the tubes can be kept clean and in a highly efficient condition.

PRIMING AND FOAMING.

It is claimed that Mosher boilers do not foam or prime with average good feed water, because of the very large steam drums with a great volume of steam space and large releasing area. Priming is usually caused by the production of more steam than can be released from the surface of the water level. In this case the whole surface of the water is literally heaved up to the steam outlet in sheets. Priming will also occur when the volume of steam space is too small, especially when supplying steam to very slow-running engines, which take large quantities of steam at widely separate intervals, causing a continuous surging of the water. Foaming is very apt to take place when first starting, or at any time, if the boilers are driven hard with forced draft. It may be due to dirty water, oil in the water or any alkali or soapy matter in the water. When foaming takes place in a properly managed boiler, checking the flow of steam will usually prevent it. If caused by dirty water or scum on the water, blowing down on the surface and bottom blows and pumping will usually cure it. In case of very violent foaming reduce the draft and partly cover the fires.

LAYING UP A BOILER.

If a boiler is not required for some time, empty and dry it thoroughly; this may be done by the use of brazier's torch, using gasoline, or a small charcoal fire may be started in each of the drums. After it is well dried out a quantity of quicklime should be placed in open pans, say 5 pounds to the pan, and left in each of the drums. Everything should then be closed up tight. The boiler should be opened at the end of a month, and if the lime is found slacked, it shows that moisture is present and the lime should be renewed. After this the lime should be renewed frequently, in any case every six months. If the boiler is only to be laid up for a short time, then fill it quite full of water, and put in a quantity of common washing soda (5 to 15 pounds, or 5 pounds for every 1,000 pounds of water) and close up tightly. All external parts exposed to dampness should receive a coating of linseed oil. The tubes or other parts of the heating surface that cannot be conveniently reached can be pretty well protected from corrosion by building a slow fire of tar or other resinous material. The tarry smoke will condense on the tubes and furnish protection from air and its moisture. Finally, close up the furnace, ash-pan and casing as tightly as possible.

REPAIRS.

Should a tube give out the fire should be drawn and the water removed from the boiler, after which the manhole covers may be removed from the steam and water-drums, giving access to all the tube ends. In case of temporary repairs the tube may be plugged by driving a tapered plug into the ends from both the steam and water-drums, the operation requiring but a few minutes. Whenever it is found convenient to replace the tube, after removing the manholes as above, and one of the hand-hole plates opposite the defective tube, the tube may be removed by splitting the ends with a diamond-point chisel, and then loosening the ends with a tool known as an oyster knife. When the tube is loose it may be driven up from the water-drum end and then passed up through the hand-hole.

To replace a tube, the new tube is passed through the hand-hole and then through the tube sheets in the steam drum, until the lower end passes through the water-drum tube sheet about ¼ inch, after which both ends may be expanded with an ordinary tube expander.

It is very important to keep the brick-work in good repair, as otherwise the casing may be warped or suffer other injuries. All bricks are secured with bolts, and any injury to the brick is localized to the brick affected, which may be easily replaced.

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CARE AND HANDLING OF A ROBERTS BOILER.

To take care of a Roberts boiler and get the most out of it, it is only necessary to give it about one-half as good care and attention as you would a shell boiler. The main points to be borne in mind are that the water level should be kept at the proper height and the fire as clean and hot as possible. If these requirements are met the boiler will steam satisfactorily, with one proviso only; that is, scale must be kept out of the boiler.

The one enemy of all watertube boilers is scale. This, however, can easily be prevented, and in this connection everyone should remember that prevention is much easier than cure, mainly because prevention eliminates all the work necessary to clean the scale out, even if the necessary apertures are provided for the purpose. No such apertures, hand-holes, manholes or plugs are provided in a Roberts boiler, however, because the manufacturers claim that the formation of scale in the boiler can, and should, be prevented.

Of course, occasionally the soot should be cleaned off the outside of the coils if it forms to any extent from the use of soft coal or wood.

Since all parts of the boiler are built in duplicate and are interchangeable, repairs can be made quickly and with comparative ease. It is only necessary to remove any given section and replace it to effect any repairs. All joints are screwed joints, which the manufacturers claim are less liable to accidents than the expanded joints which are usually used in boiler work.

HOW TO GET THE BEST EFFICIENCY FROM A COCHRAN DONKEY BOILER.

The primary object of the donkey boiler is to relieve the main boilers of the arduous and exacting duty of discharging cargo and driving the auxiliary machinery when the vessel is in port. That the main boilers be kept in good condition, clear of dirt and scale, and not subjected to sudden changes of temperature, is the constant aim of the engineers in charge, and this can only be accomplished by devolving the dirty work upon the long-suffering donkey. The donkey, therefore, usually has to be content with water from the ship's side, as salt as the sea can make it, and perhaps, if the sea-cock is near the vessel's bilge, with a good supply of mud as well. Furthermore, it is invariably heavily overloaded. There is therefore much to be said regarding the handling of the donkey to get the greatest efficiency from it.

In the first place, let the donkey boiler be large enough, and let the same attention to cleaning it be given when it is off duty as is given to the main boilers. Its size must be considered in relation to the duty it has to perform. Not only must the size and number of winches to be driven be taken into account, but consideration must also be given to the class of cargo to be worked. Coal whipping and grain cargoes call for very strenuous work on the part of the donkey, particularly when working on the bottom half of the cargo. Steam is required in a continuous supply, and if the winches are in poor condition the strain is very great.

The following shows the amount of heating surface which has been found to give satisfactory results, and which should always be insisted on by owners. Even a still larger heating surface is well worth the slight extra money involved:

One 5-inch double-cylinder winch requires from 50 to 60 square feet heating surface.

One 6-inch double-cylinder winch requires from 80 to 100 square feet heating surface.

One 7-inch double-cylinder winch requires from 100 to 120 square feet heating surface.

One 8-inch double-cylinder winch requires from 140 to 160 square feet heating surface.

Having seen that the donkey boiler is large enough, the next point requiring attention is the position of the boiler in stokehole and the lead and size of the chimney. The boiler must be so placed that an ample supply of fresh air shall be available for combustion, and it is very important that a good ventilating shaft should be brought near to the front of the boiler.

More important still is the funnel. The donkey boiler must have a funnel of its own, the longer the better, and the same size as the opening on the top of the smoke-box. To reduce the diameter is absolutely fatal to the steaming capacity of the boiler. Again, if the donkey funnel is led into the main funnel it must be led to the top of it. There is no use merely leading a short length of funnel from the donkey to the main funnel, and expecting the main funnel to create a draft for the donkey boiler. Any draft created in the main funnel will only be drawn from the main boilers, or more probably still, from the main smoke-boxes, whose doors are often open when steam is off the main boilers.

The next point to consider is the feed water and the internal cleaning of the boiler.

As has already been pointed out the donkey boiler has to be content with salt, and often muddy, water, with the result that much scale is deposited on the heating surface. Provided that this scale is not allowed to get too thick, no undue overheating need take place, but it is imperative that it be removed at the very first opportunity available. It is also a *sine qua non* that the donkey boiler must be so designed that the scale can be readily removed and all parts of the heating surface be accessible for this purpose.

The cleaning of the donkey boiler should be attended to immediately after the vessel leaves port, and not left, as is so often the case, to the day before it is to be used again. It is quite possible that in the two or three days it may have been at work a deposit of ⅛ inch may have formed on the furnace, back tube plates and tubes, and this deposit will usually contain not only common salt and mud but a number of other ingredients, such as magnesium chloride and other hygroscopic salts, which are positively injurious to the steel and iron of which the boiler is constructed. These chemicals, in conjunction with damp heat, will often set up rapid corrosion in the tubes and plates of the boiler, and in a few years, or even less, serious trouble may accrue.

It is recommended that all this scale be removed at the very earliest opportunity, and after having been thoroughly washed out, the boiler should be carefully dried inside and made airtight by the shutting of all cocks and valves and the proper joining up of the manhole and mud-doors.

It cannot be too strongly borne in mind that, unlike the main boilers, the depreciation of the donkey boiler does not take place during the period it is under steam, but during the long periods when it is out of use, and the chemical scale and damp, hot atmosphere inside it are eating into its material during its idle time on the voyage.

Turning to the question of stoking, much sympathy must be bestowed upon the donkey man. His lot is not a happy one, for, as in the case of the donkey boiler itself, the impossible is too often expected of him. Feeling the hopelessness of doing what is wanted, the cruel logic of the situation seizes him, and he does not attempt it, and ends by doing even less than might reasonably be expected. The result is in all probability a dirty fire, sooty tubes, and, worse than all, a choked-up ash-pit, with the consequent overheating and dropping out of the fire-bars. To get the best results out of the donkey boiler it is imperative that the ash-pit be kept clear of ashes to allow of a copious supply of air to the under side of the fire.

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PRACTICAL LETTERS FROM MARINE ENGINEERS.*

Experiences Relating to the Design, Care and Handling of Marine Engines, Boilers and Auxiliaries; Breakdowns at Sea and Repairs.

Boiler Corrosion.

One of the most dangerous faults which may develop on board a steamship, after a certain amount of wear and tear, is the corrosion of the boilers, and a considerable amount of close attention and inspection is required in order to safeguard the boat against danger from this cause. Boiler corrosion is due to three main causes—air, acid and galvanic action. Of these the two former, air and acid, enter the boiler from the outside with the feed water, while galvanic action is set up inside the boiler by the heat and either alkaline or acid water acting on the different metals employed in the boiler.

Corrosion, however formed, shows itself in pitting and eaten surfaces, and it is usually found at points where the heat impinges on the boiler to the greatest extent. These surfaces are generally along the lines of the fire-bars on the water-side of the furnaces, on the sides, bottom and middle of backs of combustion chambers, also in a lesser degree on the combustion chamber stays nearest to the combustion chamber, and sometimes on the main stays nearest to the uptake end of the boiler. All of these parts should be very carefully examined when a boiler is laid off for repairs or while in dock. On the external surface of the boiler corrosion is caused by rust and by any burning of the heated surfaces which may take place. There is another kind of corrosion, technically called "grooving," which is sometimes found at the seams of the boiler, and is due to the mechanical action on the metal owing to expansions and contractions of the boiler.

In order to avoid the various types of corrosion mentioned above it is necessary to adopt certain precautions and remedies, which may be detailed as follows: It should be reckoned as an axiom that air should be excluded from a boiler as much as possible, as it tends to rust and corrode the plates. A most useful means of performing this is by the use of feed heaters, in order to thoroughly heat the water before entering the boiler. This not only drives off a large amount of contained air, but also, by sending the water into the boiler in a hot condition, tends to keep up a better circulation in the interior of the boiler; bad circulation is a very potent cause of corrosion of boilers, inasmuch as there is always a certain amount of oxygen in the water, which is liberated by heat. If a boiler has bad circulation this free oxygen attacks the metal plates and forms rust; whereas in a boiler possessing good circulation the free oxygen is detached from any surface upon which it may happen to rest and rises to the steam space.

In order to safeguard against exposed metal surfaces forming a favorable opportunity for rusting, new boilers should be lime-washed in the water and steam spaces before using, and if rust is found on the plates after the first running the lime-washing should be repeated. In the meantime a scale should be induced on the boiler plates by keeping the density low by means of scumming, and also by the use of lime added to the feed water. This, of course, should only be used in moderate quantity, as only a very thin scale is required in order to protect the interior of the boiler from rust.

It will be easily understood that acids attack boilers very readily, and these are brought into the boiler by the feed water. The chief source of this acidity is the decomposition of oil, which arises from a too frequent internal lubrication of the engine. Where lubrication is necessary only the best mineral oil should be used for the pistons and piston rods. Moreover, the gland packing should preferably be greased by mineral oil rather than with the tallow which is so frequently employed. Animal and vegetable oils always decompose in the high temperature of the boiler, and cause the formation of acids, whose action, if not checked, induces a great amount of corrosion and pitting. As pitting, if once started, is exceedingly hard to stop, the boiler water should be frequently tested for acidity by means of litmus paper.

If such boiler-feed waters are discovered to be acid by this test, soda or soda and lime should be added to the feed water, preferably in small quantities administered every day, although in engines which under regular conditions will run almost without internal lubrication the use of soda need not be so frequent. In one very bad instance of pitting and corrosion, a set of boilers which was attacked in this way was always opened out when in port and the corroded surfaces were scraped clean and washed with soda after being coated with lime-wash. This was done regularly, the result being that the pitting did not get any worse. In order to prevent oil from entering the boiler, even if it is necessary to use it in the engine lubrication, it is advisable to fit efficient oil filters in the feed-water service, so as to intercept any particles of oil before passing to the boiler. For seagoing practice, filters employing cores are the most suitable, as the filtering medium can be readily changed, even on the longest voyage.

One of the most fruitful causes of corrosion and pitting is galvanic action, and this is prevented by the use of zinc plates hanging in the water space of the boiler. These plates are attached to suitable hangers, having a proper metallic connection with the plates of the boiler. They should also be attached to the stays, furnace tubes and combustion chamber stays. Galvanic corrosion is thus transferred to the zinc, which is thus eaten away and the iron and steel preserved. It is found in practice that zinc plates are better than zinc balls connected to the boiler parts by wires, which is a frequent arrangement, inasmuch as the wires do not make a perfect connection.

It may be mentioned that although there are at the present time many liquids manufactured for the purpose of preventing boiler corrosion, these are not generally used in marine practice, and, generally speaking, it is hardly advisable to adopt them except under very careful skilled advice. Some of these liquids, as a matter of fact, do considerably more harm than good.

External corrosion of the boiler is a matter which can to a greater extent be more easily and immediately detected than internal corrosion. It can, as a rule, be prevented by keeping the mounting glands tight, and by seeing that the surface is thoroughly treated with a good composition or a covering of red lead and paraffin. The mattresses or boiler coverings should always be kept in good order and condition, and if attention is paid to these points of up-keep it is probable that the danger from corrosion will be very largely minimized, if not altogether obviated.

A. H. S.

Circulating Valves.

The type of valve which is usually used on board ship for circulating pumps, ballast donkeys and bilge pumps is con-

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structed of rubber, and the maintenance of these valves is a very costly item in the upkeep of a boat. On examination of such valves, after a period of running, it will be found that the part at which the valves wear to the greatest extent is at the center hole. This is easily understood from the fact that with the constant wear on the spigot bolt the hole gradually widens and wears too big until part of the ports in the valve seat are left open. In this way the vacuum of the pump is spoiled.

In order to obviate this difficulty a simple device has been tried which, as a matter of fact, has been found to increase the life of the valve roughly four times, and, therefore, causes a considerable saving. A piece of 1/32-inch Muntz metal is cut into a strip equal to the thickness of the valve. It is then bent round the spigot bolt, so as to form a loose fit and cut off accurately to length so as to form a true cylinder. This cylinder is then fitted into the center hole of the valve, and by means of this piece of strengthening metal it will be seen that the wear is now on the Muntz metal instead of on the valve, and a considerable saving is thereby effected.

CHARLES P. STARKWEATHER.

Breakdown of a Reversing Gear.

In spite of the precautions taken to make the factor of safety of ships' machinery considerably in excess of any reasonable demand it sometimes occurs that mishaps happen, and in the case of the reversing gear this usually occurs at the most anxious time to the engineer; that is to say, when the boat is going into or leaving port. Such an accident may happen because the drain cock has not been opened and the water in the cylinder causes a breakdown to the gear. Possibly this is accompanied by the cutting away of the cylinder bottom, the fracture of the connecting-rod pin or the bending or fracture of the slide rod.

In most steamers the steam reversing gear can be operated by hand, but it will be realized that this is a very slow process. It is not by any means capable of use in working the ship into or out of port, as it is usually necessary to move the ship quickly.

A very rough but good plan to adopt in cases where any stoppage to repair the gear would be dangerous or expensive to the owners would be to take the L piece of a drilling standard, and clamp this on to the wheel as quickly as possible. By bringing two firemen from the stokehold to turn the wheel it is possible to handle the boat quickly, as this arrangement gives a good leverage, using the L piece as the handle. If there has been further trouble, such as bent rods, it is necessary, of course, to quickly discount these. R. A. BRUSH.

Overheated Tunnel Bearings.

Designers of marine engines and machinery sometimes forget that a steel steamer is to a certain extent flexible, and should be considered somewhat in the light of a lattice girder, which is alternately supported at the ends and in the middle. There is, however, this difference, that whereas the composition and loading of the girder are uniform, those of a ship vary from time to time. For example, a steamer when loaded with grain may take up a certain slight distortion, while in the same ship, when loaded with iron, an entirely different distortion may occur, a third condition arising when the boat is light.

This variation in the condition of the hull reflects itself in the varying degrees of attention which have to be paid to the bearings in which the propeller shaft runs. In one case, No. 1 or No. 2 tunnel bearing may run warm when the ship is loaded with grain, and when the ship is light the same bearings may run quite cool. As a matter of fact, in some boats which leave port with different cargoes it is impossible to tell which bearing is going to run warm. In one instance a bearing became so hot due to this cause that the white metal melted away.

In order to remedy this occurrence, if it happens at sea, a method adopted is to take a hardwood block and cut a small V in its center. This should then be wedged up under the shaft on either side of the bearing. There is always room for this to be done on the plummer block. When the weight of the shaft has been taken in this way on the wood block, it is safe to draw the bolts and take away the bottom brass, running this up again with white metal.

This may seem a rather risky expedient, but it very often happens that it would be very unwise to stop the vessel for such a repair, and if plenty of oil is kept on the block the shaft may be found to run quite well. It is advisable to have a hammer lying near the block, so that the engineer on watch going along the tunnel every hour may knock in the wedges as the hardwood block wears away. EXPERIENCE.

Sewer Gas in Boilers.

When I was second engineer of an Atlantic liner sailing from the River Clyde, I had an experience which was interesting. Before the installation of the sewage-treatment plant at Dalmins, the Clyde used to become very "strong" in the summer months. We were lying at the quay during one of these periods, and I sent the third engineer to open up a valve through which we had been pumping Clyde water. He had an open lamp with him, and when he lifted the cover an explosion took place, and he was rather severely burned.

On making inquiries I found that this was not an isolated case, as I was told of an explosion which had occurred when taking off a condenser door. Probably a mixture of air and marsh gas made the explosive mixture.—*M. C. Gillean, in Power and the Engineer*

BARCELONA, SPAIN.

A Novel Steamship Repair.

An account of the replacement of a broken tail-shaft in the large steam tug *Dolphin*, belonging to Messrs. S. Pearson & Sons, is given by John Marshall, 14 West Bute street, Cardiff. He states that this vessel was lying in fairly deep water in the harbor at Sulina Cruz, on the Pacific Coast of Mexico. In the operation the propeller was first removed by a diver, and then the tail-shaft was drawn in towards the engine. To prevent the inrush of water, the diver slipped into the stern-tube a taper wooden plug, around which was an india rubber ring, to make it watertight. This was forced in and afterwards secured by means of a wooden chock wedged in between the head of the plug and the rudder post. The new tail-shaft was then put in place. Between the fore-and-after sleeve there were fitted wooden battens to make up the space between the sleeves, and to render the shaft of the same diameter throughout its length. These battens were kept in place by bands of copper wire laid in grooves prepared in the battens to receive them. When the new shaft was in the stern-tube the packing and the gland were replaced and screwed up sufficiently to prevent a rush of water. A jack was then placed at the inner end of the shaft, which was forced into its place, pushing out the plug from the stern-tube. The propeller was put on by the diver, and finally hammered up by means of a dolly slung and manipulated from the deck and guided below by the diver.—*The Steamship.*

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Boiler-Room Economy.

Economy in the boiler room of a steamship depends not only upon the design of the boiler, the design of the furnace and the quality of fuel used, but also upon the skill of the firemen and the care and management of the boilers. Obviously a well-proportioned boiler will not prove efficient if the heating surface is allowed to become coated on one side with a thick scale and on the other with a covering of soot and ashes. Neither will a well-designed furnace produce complete combustion if the fuel is improperly fired or the distilled gases prevented from mixing with the proper amount of air at a temperature necessary to support combustion. Above all, no problem of boiler economy should be considered by itself. It should be remembered that every factor entering into the design and operation of a steamship is more or less the result of a compromise; that, in fact, the entire vessel is essentially a compromise; and, consequently, every problem of economy should be considered in relation to the entire vessel, taking into account the limits of weight, space and cost available, and the purpose for which the vessel is to be used.

Two separate and distinct processes are carried out in a steam-generating plant: first, the combustion of the fuel; and second, the evaporation of the water into steam. There are many opportunities for losses in both of these processes, and, unfortunately, things which tend toward economy in one direction are frequently the very things which cause loss of efficiency in the other. For instance, in order to burn bituminous coal it is necessary to first distil the gases from the coal, then mix them with the required amount of oxygen and maintain a proper temperature for their combustion. For this reason it is an advantage to keep the gases at a high temperature in the furnace as long as possible. On the other hand, the evaporation of the water requires that the heat thus generated shall be extracted from the gases in the shortest possible time. In the present-day steam plant the former process has reached a higher degree of perfection than the latter.

As far as the latter is concerned, little is actually known regarding the rate of transmission of heat from hot gases through metallic surfaces to water. Rapid circulation of the water in the boiler and of the gases through the boiler apparently tend to increase the rate of evaporation, as has frequently been proved by the simple experiment of stopping up half of the tubes in a locomotive boiler and maintaining the same rate of combustion on the grate. Obviously the gases must pass through the tubes with twice the velocity, and the corresponding rate of evaporation per square foot of heating surface is doubled. This is accomplished without any great decrease in the efficiency of the furnace. Also, in a recent installation of stationary boilers two furnaces were installed under the same boiler, one at the front and one at the back. The result was that the evaporative power of the boiler was nearly doubled, with a loss in efficiency of only about 3 percent. Further corroboration of these results is found in recent experiments made by the United States Geological Survey, which seem to indicate that boilers should be made to do from ten to twenty times as much work per unit area of heating surface as they do now. This great increase is to be accomplished by forcing the hot gases through the boiler at a very much greater velocity than is now customary, as it has been found that the faster the gases travel parallel to the heating surface the greater the amount of heat which is transmitted from them to the water in the boiler, due to the removal of the cooled-off gas particles, which cling to the heating surface, forming a film which greatly retards the transfer of heat, and the bringing into con-

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tact with the dry side of the heating surface other heated particles of gas. It is probable that improvements in design may soon be made along the lines vaguely suggested by the foregoing experiments; and if they are, even though they involve a decrease in efficiency in the steam-generating plant as such, due to the rapid combustion of large quantities of fuel, yet they would be readily welcomed for marine work, since they would undoubtedly permit a substantial reduction in boiler weights and space.

As we have previously stated, however, boiler-room economy does not depend entirely upon improvements in the design of boilers and furnaces. Skillful firing and the intelligent care and management of boilers are equally important. When watertube boilers were first being advocated for merchant vessels in the United States an installation of Belleville boilers was made in the passenger steamships *Northwest and Northland,* on the Great Lakes. These boilers gave considerable trouble for various reasons, and were subsequently replaced by Scotch boilers; but for one season the watertube boilers ran with a fair amount of success. This success was attributed to the fact that Spanish firemen were imported for working the boilers. The Spanish firemen were more or less familiar with this type of boiler, and were employed for the entire season, so they were able to become thoroughly familiar with their work, and since they were unable to speak English, they simply obeyed the instructions of the head fireman, who knew exactly how the boilers should be managed in order to get the best efficiency from them. Thus they were able to do what American firemen, who were only familiar with the firing of Scotch boilers and who rarely stayed on the ships long enough at a time to learn to fire the Belleville boilers, were unable to do. This is only one of many instances that might be cited to show the importance of proper firing in the economical management of any steam plant.

The importance of firing is brought out strongly in the various articles which we publish this month giving instructions for the care and management of different types of boilers in order to get the greatest efficiency from them. Undoubtedly Scotch boilers are the easiest to fire, for the grates are limited to practically uniform dimensions, and the height of the top of the furnace above the fire is so small that it is a comparatively easy matter to maintain an even depth of fire and to regulate it according to the nature of the draft, etc. With watertube boilers, however, not only are the furnaces usually much larger, but they differ radically in different types of boilers, due to the different directions in which the gases travel and the different means supplied for admitting air to the hot gases. Under such conditions it is a positive necessity that the fireman should have both good judgment and a good, practical knowledge of the special needs of the particular boiler on which he is working. Good judgment is required particularly when firing under forced draft with a closed stokehold, for under these conditions it is seldom that the fire will burn evenly all over the grate. "Light, even and often," is a rule often quoted to firemen, and it is a good one to follow, provided the fire burns evenly. The fireman should take pains to watch the fire carefully, however, and keep those places which tend to burn through more rapidly well covered, so as to prevent an excess of air from entering and spoiling the combustion. The sides and corners particularly should be given careful attention.

Mechanical stoking and oil fuel have frequently been proposed as the most logical means to escape the troubles and losses of efficiency due to poor hand firing. Mechanical stoking, however, means the feeding of a uniform quantity of fuel to all parts of the fire; and while this is satisfactory with natural draft, it becomes distinctly questionable with heavy forced draft in a closed stokehold where there is a tendency on the part of the fire to burn out more rapidly in the center. It may be possible to construct a stoker which will admit of sufficient regulation to overcome this difficulty, but at present they are not widely used for this purpose. Mechanical stoking, considered by itself, offers many striking advantages over hand firing; but when considered in the light of weight, space and cost in relation to the design of the entire ship, some of these advantages are eliminated and some serious disadvantages introduced. This is a matter, however, on which there has been little enough progress in the past, and which we hope to see given more attention in the future. Good results have already been obtained with some types of stokers in certain kinds of service, and these, we believe, will be steadily augmented.

Oil fuel, on the other hand, has proved quite generally successful, as evidenced by its use in naval vessels, and also its extensive use in merchant vessels running between ports where there are petroleum fuel-storage stations. On the Pacific Coast there are about one hundred and forty steamers using petroleum as fuel. Besides regular firing, easy control of the fires and the elimination of coal and ash handling, liquid fuel permits a reduction in the weight of fuel carried that tends directly towards economy not only as regards the boiler plant itself, but also as regards the design of the vessel as a whole. From the standpoint of absolute economy, therefore, oil fuel presents no disadvantages other than the cost of the fuel itself.

One more subject should be strongly emphasized in considering the question of boiler-room economy, and that is the importance of clean boilers. All scale and deposits should be removed from the heating surfaces at the earliest possible moment if their formation cannot be avoided. As far as possible, however, scale and deposits of any kind should be prevented from forming in the boiler.

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Progress of Naval Vessels.

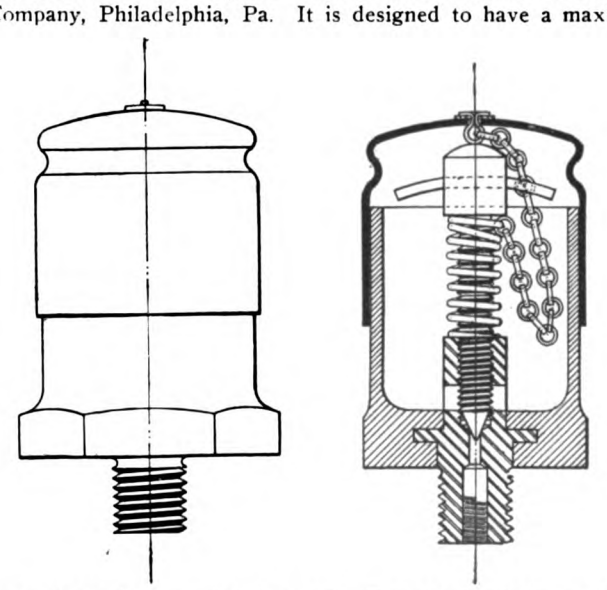
The Bureau of Construction and Repair, Navy Department, reports the following percentages of completion of vessels for the United States navy:

	Tons.	Knots.		Sept. 1.	Oct. 1.
BATTLESHIPS.					
S. Carolina..	16,000	18½	Wm. Cramp & Sons.....	98.0	99.0
Delaware ...	20,000	21	Newp't News Shipbuilding Co.	94.8	96.8
North Dakota	20,000	21	Fore River Shipbuilding Co..	93.5	95.2
Florida	20,000	20¾	Navy Yard, New York.....	29.2	33.7
Utah	20,000	20¾	New York Shipbuilding Co...	38.1	44.4
TORPEDO-BOAT DESTROYERS.					
Smith	700	28	Wm. Cramp & Sons.....	96.4	98.4
Lamson	700	28	Wm. Cramp & Sons.....	90.3	91.4
Preston	700	28	New York Shipbuilding Co...	93.0	94.8
Flusser	700	28	Bath Iron Works.....	92.4	100.0
Reid	700	28	Bath Iron Works.....	89.6	94.3
Paulding ...	742	29½	Bath Iron Works.....	27.3	36.3
Drayton	742	29½	Bath Iron Works.....	24.6	30.5
Roe	742	29½	Newp't News Shipbuilding Co.	60.9	64.6
Terry	742	29½	Newp't News Shipbuilding Co.	58.5	63.9
Perkins	742	29½	Fore River Shipbuilding Co..	51.7	56.0
Sterrett	742	29½	Fore River Shipbuilding Co..	48.6	53.4
McCall	742	29½	New York Shipbuilding Co..	25.3	29.6
Burrows	742	29½	New York Shipbuilding Co..	25.4	29.2
Warrington..	742	29½	Wm. Cramp & Sons.....	39.1	47.3
Mayrant	742	29½	Wm. Cramp & Sons.....	45.2	51.5
No. 32.....	...	....	Newp't News Shipbuilding Co.	0.6	1.1
No. 33.....	...	....	Bath Iron Works.....	2.2	4.0
No. 34.....	...	....	Fore River Shipbuilding Co..	0.0	3.2
No. 35.....	...	....	Fore River Shipbuilding Co..	2.5	5.3
No. 36.....	...	....	Wm. Cramp & Sons.....	0.0	1.7
SUBMARINE TORPEDO BOATS.					
Stingray	...	..	Fore River Shipbuilding Co..	97.5	99.1
Tarpon	...	..	Fore River Shipbuilding Co..	98.8	99.1
Bonita	...	..	Fore River Shipbuilding Co..	92.0	99.0
Snapper	...	..	Fore River Shipbuilding Co..	92.0	99.0
Narwhal ...	...	..	Fore River Shipbuilding Co..	98.2	98.9
Grayling	...	..	Fore River Shipbuilding Co..	91.8	98.5
Salmon	...	..	Fore River Shipbuilding Co..	83.7	86.7
Seal	...	..	Newp't News Shipbuilding Co.	24.8	26.2
Pickerel			The Moran Co.....	8.4	10.7
Skate			The Moran Co.....	8.5	10.6
Skipjack	...	..	Fore River Shipbuilding Co..	0.0	7.6
Sturgeon ...	...	..	Fore River Shipbuilding Co..	0.0	7.6
Tuna	...	..	Newp't News Shipbuilding Co.	3.0	3.8

ENGINEERING SPECIALTIES.

The U. S. Indestructicle Oil Cup.

The illustration shows both sectional and exterior views of a new indestructible oil cup, which is being manufactured and placed on the market by the United States Metallic Packing Company, Philadelphia, Pa. It is designed to have a maximum strength at a minimum cost. The shank of the cup is of machinery steel and it is consequently impossible to break it when screwing down the same, as is sometimes the case with the brass cup of similar design. The cover is of pressed steel and is attached to the body of the cup by a steel chain. This precludes the possibility of losing it by its jarring off, or, as is often the case with brass cups, from stealing.



The indestructible oil cup will be furnished either with a needle or wick feed, as may be desired, and with shanks of any desired diameter and number of threads. The standard cup, as shown in the illustration, has a ¾-inch diameter shank and 14 threads. The method of manufacture of this cup makes it possible to sell it at a low figure, and this, together with its mechanical features, will, it is believed, make it quite popular.

New Starrett Products.

Fig. 1 shows some new tool makers' buttons with screws and washers for jig work which have just been placed on the market by the L. S. Starrett Company, Athol, Mass. These buttons are hardened and ground to standard size, .400 by ½ inch, and are used to locate holes to be chucked and bushed for jigs where positive accuracy is required. In use the jig piece is laid out, prick-punched, drilled and tapped for button screws, and then the burr smoothed off. The buttons are then fastened on, strapping the pieces to an angle-iron, placing same on a surface plate, where, by aid of a surface gage, height gage, or other instrument, the buttons (with holes larger than the screws) are brought to the desired location. The angle-iron with the button pieces are then strapped to the lathe face plate, bringing one of the buttons to run true with the center. After this has been done, remove the button and chuck and ream the hole. The operation can then be repeated with the other buttons until all the holes are chucked.

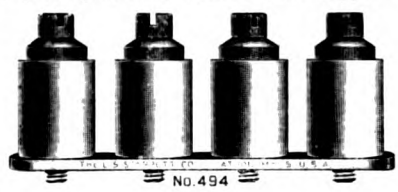


FIG. 1.

Fig. 2 shows a new carpenter's scratch gage, which has just been placed on the market by the same concern. The head of this gage is made of steel with octagon-shaped periphery, case-hardened. Two 5/16-inch bars, one plain, 4 inches long, and one graduated in thirty-seconds of an inch, 8 inches long, with rotating cutters on the ends, slide through the head. Either is adjustable in relation to the other, and may be used to make two marks at once, or, by slipping one back into the head

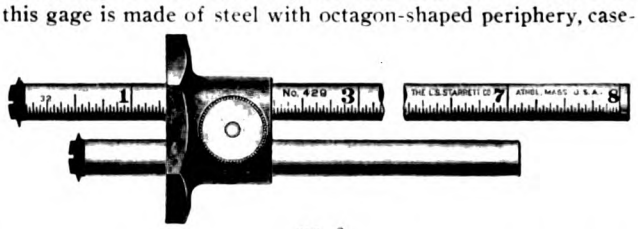


FIG. 2.

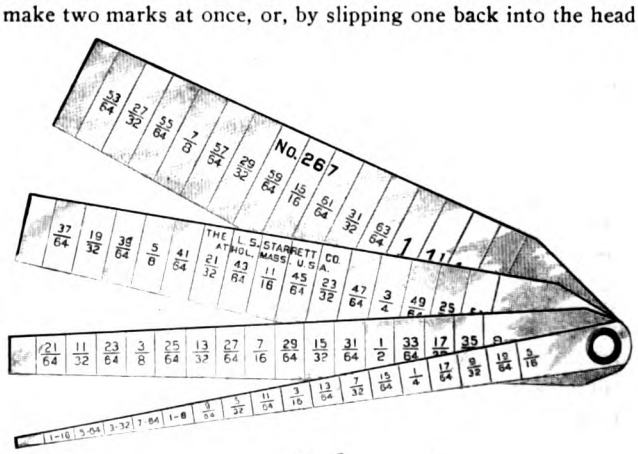


FIG. 3

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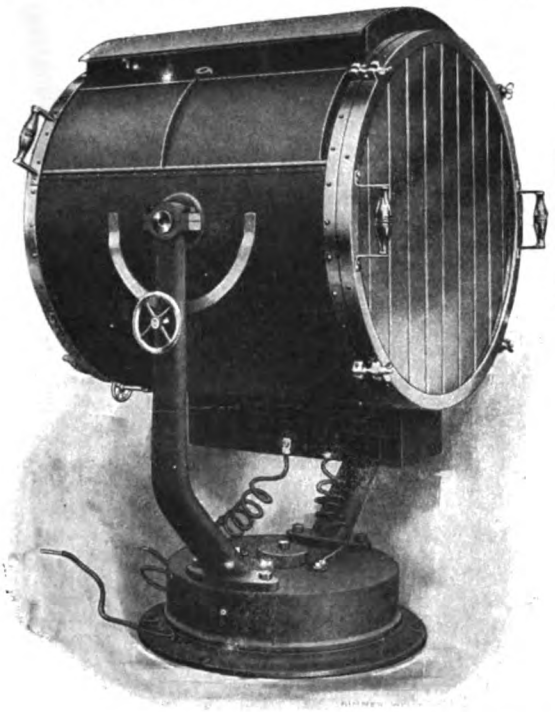
out of the way, the other bar may be used for single lines. A single fastening screw holds both bars in position.

A new taper gage, in which the leaves are very thin and tapering, the width varying by 1/64 inch to every quarter inch of their length, is shown in Fig. 3. The leaves are graduated in quarter inches, and figured to read in fractions of an inch from 1/16 up to 11/16 inches.

Marine Electric Searchlight.

The Carlisle & Finch Company, Cincinnati, Ohio, has recently brought out several improved types of searchlights, which are particularly adapted for seagoing vessels. The type illustrated is a 32-inch projector of the hand-control type. This searchlight is very powerful, throwing practically a straight beam of light for several miles. It is fitted with a parabolic glass mirror, ground as accurately as possible, and is so supported as to allow for expansion from heat. These



projectors are made in various sizes, from 7 to 38 inches diameter, and are arranged to be controlled from the pilot-house, or with distant hand-control rigging, or for hand control. It is claimed that the carbon-feeding mechanism is so reliable and so positive that it will burn in any position, and that it is not affected by the weather.

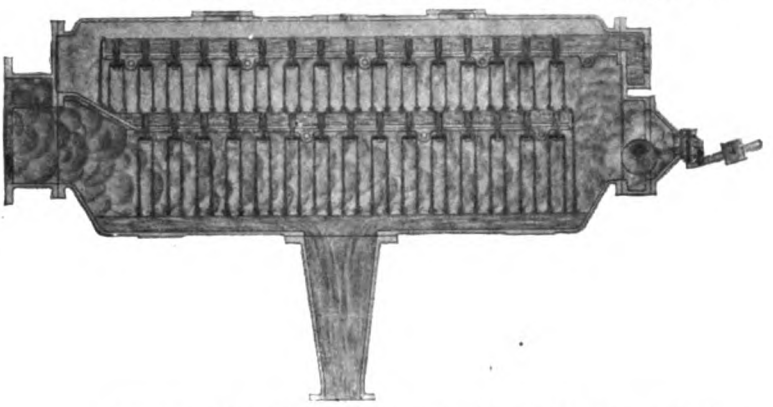
A New Form of Jet Condenser.

A new form of jet condenser has recently been placed on the market by the Wheeler Condenser & Engineering Company, Carteret, N. J. Referring to the illustration, the water is introduced at the upper right-hand corner into an extended trough or pan, from which it overflows through numerous short tubes, also at the edge on the extreme left, falling into a second and similar pan provided with similar overflow pipes and weir, and finally falling into the lower part of the shell and overflowing thence to the barometric column or to the centrifugal or other type of pump serving to overcome the atmospheric pressure.

The steam enters through the opening at the left, passes horizontally across through the shower of water, ascends to the second level, passes to the left through the upper shower, and finally all that is left of the steam vapor, together with the air and other gases, passes horizontally to the right and over the entering and coldest water at the top to the dry vacuum pump suction opening in the uppermost part of the shell. The cross-section of the passage traversed by the steam continuously diminishes as the volume of steam is reduced by condensation. Therefore, a uniform, steady velocity is maintained throughout, leaving no dead pockets in which air might accumulate.

From the illustration it will be seen that it is impossible for any of the steam to pass to the air pump suction without having traversed all of the space. The water is finely divided by the small baffles hung below the tubes. At the right of the illustration will be seen a float, controlling a vacuum-breaking valve. In case the water level should rise abnormally in the shell, due possibly to stoppage of the circulating pump, this will break the vacuum, upon which the inflow of water will cease, since the circulating water is syphoned up to the condenser head from a lower level. The steam would then escape through the relief valve.

Tests made on this condenser in actual service show that the innovations briefly outlined above have worked to good ad-



vantage. Not only have the tests shown that extremely low vacua can be maintained, but also that the final temperature of the circulating water is very nearly that of the steam. In one test, where the injection valve was set to care for the maximum of a widely varying load, the outgoing circulating water was maintained within from ½ to 7½ degrees of the temperature corresponding to the vapor pressure.

Blake Patent Boilers.

The Blake Patent Boiler, built by the Blake Boiler, Wagon & Engineering Company, Ltd., Darlington, is very extensively used on steamships as an auxiliary boiler for driving the winches, etc., and on land for general purposes; it is specially adapted for utilizing the waste heat from furnaces. The chief requirements of boiler users of to-day are that the boiler shall steam quickly and easily with an economical consumption of fuel, and that it shall be easily accessible for cleaning and examination. It is claimed that the Blake boiler fulfills these requirements very easily; it has a large, spacious furnace and combustion chamber, in which the gases evolved from the fuel and the air can mix together, giving complete combustion. The gases pass from the combustion chamber to the smoke-box through a large number of small tubes surrounded by water. The draft is quite free, and there is no necessity for wasteful steam jets to draw the gases to the funnel. The tubes are arranged with wide spaces between them, so that the passage of steam from the furnace and combustion-chamber plates and the tubes themselves is very much facilitated, thus promoting a rapid, positive circulation and abundant generation of steam. The boiler has great durability, because it is very accessible for cleaning purposes, consequently it can be

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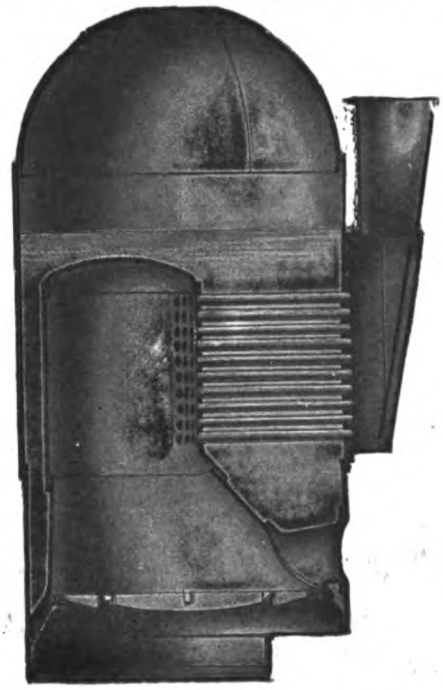
kept in an efficient and safe condition at a very moderate cost. Another special feature is its great strength, requiring neither screwed stays nor stay tubes. The circularity of the shell is not broken by the introduction of flat tube plates, and the boiler is consequently free from panting and the attendant



leaky parts. A special formation is imparted to the tube plates around the tube holes, whereby these parts are brought square with the tubes; thus oblique tube holes are avoided and a sound joint ensured by rolling with an ordinary tube expander.

No brick-work setting or expensive foundations are required for these boilers, and they are built in sizes from 9 feet high by 4 feet diameter to 18 feet 6 inches high by 8 feet 6 inches diameter.

Bronze, Brass, Aluminum and Babbit Metal for Marine Work.

The Vanadium Metals Company, Frick building, Pittsburg, Pa., has been organized for the purpose of manufacturing bronze, brass, aluminum and babbitt metals. This company has purchased the secret processes of the Victor Metals Company, of Massachusetts, which include Victor bronze, Victor vanadium bronze, Victor non-corrosive silver metal and Azalea antifriction metal. By the incorporation of vanadium in these compositions it is claimed that the strength and toughness has been wonderfully increased, and, as vanadium is a perfect scavenger, a very clean and uniform metal is insured.

Victor vanadium bronze has been used in all of the submarine boats built by the United States Government within the past few years, and also in foreign vessels of this type. In fact, this composition, or its equivalent, has been standardized by the Government for all the heavy castings in this type of vessel, where extraordinary strength is required. For cold-rolled plates, rods and wire the following figures are claimed:

	Ultimate Strength Per Square Inch. Pounds.	Elastic Limit Per Square Inch. Pounds.
Plates	95,370	76,940
Rods	92,090	80,070
Wire	101,000	83,180

Victor non-corrosive silver needs no introduction to the metal industry. It is claimed that it does not corrode when exposed to the elements or to acids of any description—vegetable or mineral—with the exception of nitric acid, and although easily polished to a bright silver color, is non-tarnishing, making it highly suitable and ornamental for all metal work on steamships, yachts, etc.

By the addition of vanadium in castings it is claimed that the tensile strength is increased to 65,000 pounds to the square inch, and the elastic limit to 45,000 pounds, thus making an ideal metal for all marine parts where great strength as well as non-corrosiveness is necessary, as this metal eliminates galvanic action of any kind whatever.

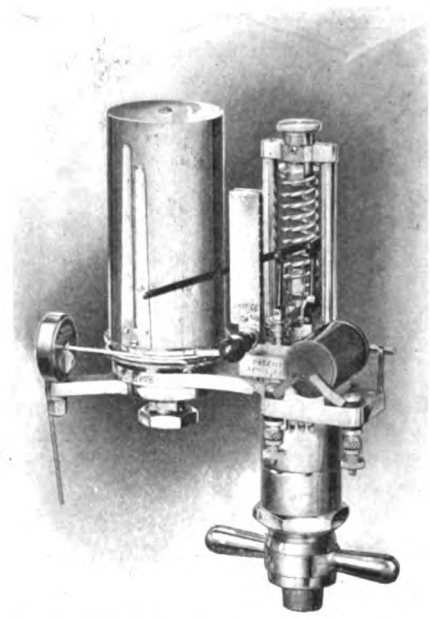
An aluminum is produced by the incorporation of vanadium, which is claimed to be 300 percent stronger.

A sheet-bar and rod mill is now under consideration, but its location has not yet been definitely determined. In the meantime arrangements have been made for the rolling of these metals and castings can be furnished up to 7,000 pounds of any of these vanadium metals.

INDICATORS.

The Tabor Indicator.

Recent improvements in the Tabor indicator, manufactured by the Ashcroft Manufacturing Company, Boston, Mass., consist principally in change of details rather than change of design. The main design, adopted many years ago, has been retained, but some new devices have been added and many of the details improved. The parallel motion of the Tabor indicator differs materially from others. A stationary plate, in



which is a curved slot, is firmly secured in an upright position to the head of the steam cylinder, or on the outside spring indicator, shown in the illustration, to a bracket on the steam cylinder. On the pencil bar is a roller bearing, which is secured to the bar by a pin. This roller moves freely in the curved slot in the guide and controls the motion of the pencil bar. The position of the slot and guide upright is so adjusted and the guide roller is so placed on the pencil bar that the curve of the guide slot controls the pencil motion, and, it is claimed, absolutely compensates the tendency of the pencil to move in an arc. This movement also involves a minimum of friction.

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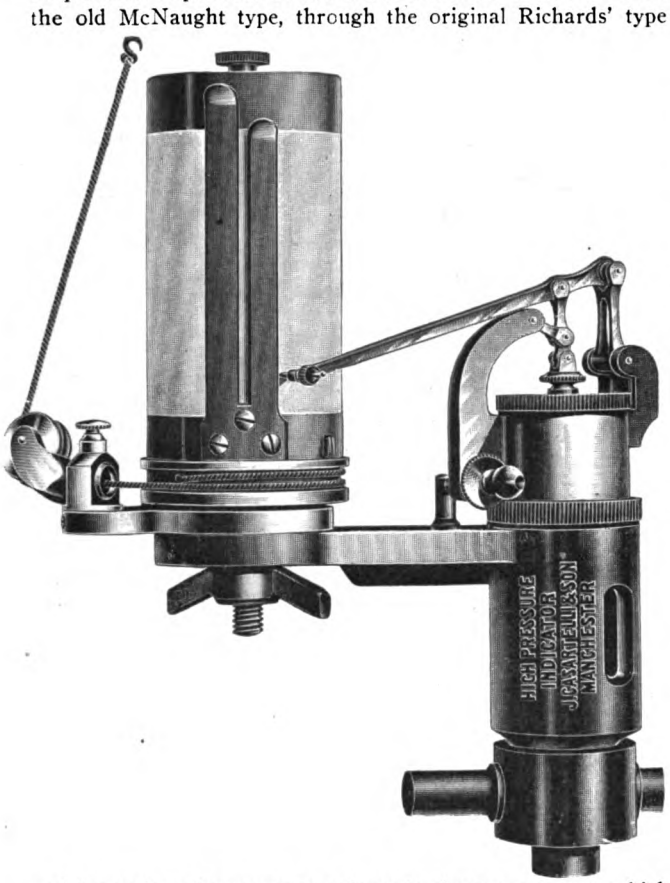
The springs used on these indicators are of the duplex type, made from two coils of wire attached exactly opposite to each other on the bases. This equalizes the side strain on the spring, keeping the piston centrally in the cylinder. It is claimed that the duplex springs are much more durable than either the single-coil or the single-wire double-coil springs, which are frequently used on other instruments. The springs are all made in different lengths, depending upon their scale, so that the atmospheric line is fixed by the spring itself without adjustment of any part. Provision is also made for a full and ample size vacuum curve.

The illustration shows a Tabor indicator with outside spring equipped with an electrical adjustment, and classed as the United States navy standard. The electrical adjustment is designed to facilitate taking cards upon several indicators simultaneously. The pencil points are operated by an electromagnet attached to each individual instrument.

The Casartelli Indicator

The Casartelli indicator, as now constructed by Joseph Casartelli & Son, Manchester, is the outcome of many years of practical experience in the manufacture of indicators from the old McNaught type, through the original Richards' type



and its various improvements down to the present type, which has quite superseded all preceding ones. The object of the makers has been to produce a thoroughly sound, well made and reliable indicator, which shall fulfill modern requirements of pressures and speeds, at a moderate price, rather than a so-called "cheap" indicator, in which price is the first consideration.

The following are the special features of the indicator: The parallel motion is of the single link type, made specially light and strong of hardened steel, and multiplying the movement of the piston six times. The piston and rod are of hardened steel and ground, and fitted with a perfect ball joint at the base of the rod, making it impossible for the piston to stick in the cylinder. The cylinder is isolated from the body of the indicator, and has the casing cut open on one side to keep it cool, and to allow of lubrication when in use. The body of the indicator, the underside of the stage, and the coupling are sheathed with a special ebonite to allow of handling when hot. The paper barrel, or roller, is of improved design, and is fitted with a spiral spring to adjust the tension on the cord as required, and the pulley guide can be swivelled and clamped in any position desired. The springs are coiled, tempered and adjusted by a special and exclusive process, yielding what is claimed to be an absolutely even scale throughout, which is guaranteed to be correct. The manufacturers claim that the Casartelli indicator is especially adapted for marine use, as it is strong, compact, easily handled and cleaned, accurate and reliable.

VARIOUS TYPES OF THORNYCROFT BOILERS.

The Thornycroft boiler has been made in various forms. The *Speedy* type was first fitted (in units of large size) to H. M. S. *Speedy,* and consists essentially of a central upper steam barrel and two smaller lower-wing barrels. A series of generating tubes is fitted between the upper barrel and each wing barrel. These tubes are expanded in the ordinary way. The tubes form practically the whole of the heating surface, and the inner row on each side is curved in such a manner as to form the top of the combustion chamber, and so protect the upper barrel. Two down-comers, of ample size, are fitted at one end of the boiler. The tubes are so arranged as to ensure the gases passing over the whole of their surface.

The *Daring* type has two parallel barrels, one directly over the other, the upper being the steam and the lower the water-barrel. They are connected by eight or nine large down-takes, generally about 4 inches diameter, and also by two groups of generating tubes, each bounded by a pair of watertube walls. On either side of the lower barrels is a fire-grate. The two fire grates are each bounded on one side by one of the two groups of tubes and on the other by the watertube wall above mentioned. These tube walls are supplied with water by a pipe connected with the lower barrels and bent round on the outer side of the grate. The gases are made to go over the whole length of the tubes by setting the fire and outer rows so as to form flue ways.

The launch type was brought out soon after the *Daring* type, and is best described by saying that it consists of half a *Daring* boiler; but instead of the tube wall taking its supply of water from a separator barrel the tubes are bent round to form the fire-grate.

The Thornycroft *Schulz* type is a modification of the *Daring* type, but the gases, in order to more fully utilize the heat contained in them, are led through specially constructed passages. The flames enter the central nest of tubes at the bottom along its whole length. The drums are connected by special down-comers.

The modern *Speedy* type is being used in most navies for both coal and oil fuel, and consists of an upper steam barrel and two smaller cylindrical lower-wing barrels. A series of generating tubes, slightly curved at the ends to allow of free expansion, connects the upper and lower-wing barrels. The curvature also allows the tubes to be put into the drums radially, thus saving weight and also allowing a cylindrical-bottom barrel to be adopted. Down-take tubes are fitted at the end of the boiler. The modern *Speedy* type of boiler is well adapted for the use of oil fuel, as a large combustion space can be obtained, and owing to the curvature of the tubes distortion does not take place under the great heat and high rate of evaporation obtained.

In connection with all the above types a Thornycroft feed

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regulator is used. This is fitted in the upper barrel, and consists of a float, which rises and falls with the water level. This is suitably connected to a valve, throttling the admission of feed water if the level is high and admitting it freely if the water level is low. Another rod comes through the front of the boiler to allow of hand regulation.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

929,564. BOAT PROPELLER. SAMUEL T. CRAWFORD, OF BALTIMORE, MD., ASSIGNOR OF ONE-HALF TO WILLIAM GREEN, OF BALTIMORE, MD.

Claim 1.—In a boat propeller, in combination, a clamp for attachment to a boat, a gear frame, a propeller frame, a tube connecting said frames and held in said clamp, said tube being mounted in said clamp for axial adjustment, a driving shaft passed through said tube and having its end portions journaled in said frames; gear means supported by said gear frame for driving said shaft, a propeller shaft having a bearing in said propeller frame, a propeller carried by said propeller shaft, and a driving connection between said driving shaft and said propeller shaft. Ten claims.

920,284. FLOATING DRYDOCK. WILLIAM THOMAS DONNELLY, OF BROOKLYN, N. Y.

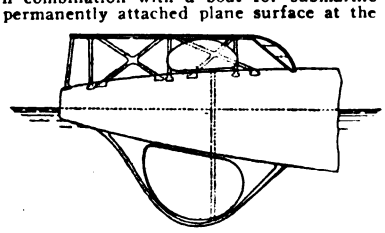
Claim 2.—In a floating drydock, pontoons, sides or wings mounted on top thereof, eyes on each side of said sides or wings, eyes on said pontoons, links, and pins designed to engage said eyes and links and connect said links to the pontoon and sides or wings. Six claims.

922,137. ANCHOR. MILAN W. HALL, OF BROOKLYN, N. Y., ASSIGNOR OF ONE-HALF TO ALFRED W. JANSEN, OF NEW YORK, N. Y.

Claim 1.—An anchor comprising a shank, a mushroom head of substantially elliptical form, and a fluke arranged to project substantially in the line of the minor axis of the ellipse of the mushroom head. Nine claims.

922,298. SUBMARINE OR SUBMERSIBLE BOAT. CESARE LAURENTI, OF SPEZIA, ITALY, ASSIGNOR TO FIAT-SAN GIORGIO, SOCIETA ANONIMA, OF SPEZIA, ITALY.

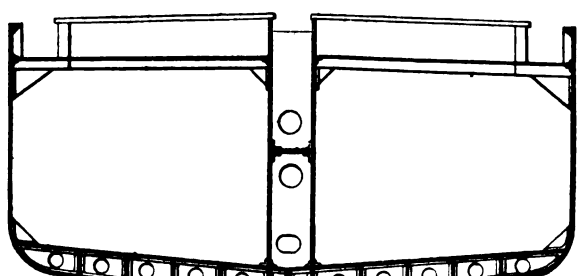
Claim 1.—In combination with a boat for submarine or submersible navigation, a permanently attached plane surface at the stern arranged



above the propelling means and at such a height above the line of flotation when the boat is navigating above water as not to be subject to the force of the waves. Four claims.

922,903. HULL CONSTRUCTION FOR VESSELS. EDWARD S. HOUGH, OF SAN FRANCISCO, CAL.

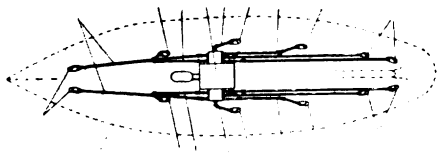
Claim 1.—A vessel having a pair of longitudinal, parallel, spaced walls inclosing on two sides a chamber the vertical center of which is



arranged in the vertical plane of the keel of the vessel, and horizontal floors or partitions subdividing said chamber into superposed compartments.—Three claims.

927,996. SYSTEM FOR PROPELLING VESSELS. THOMAS MOTTON, OF TORONTO, ONTARIO, CANADA.

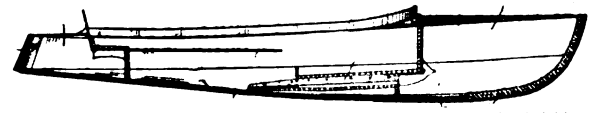
Claim. 2.—In a system for propelling vessels, of a plurality of outlet ports through the hull, an air compressor suitably situated in said hull,



conveying tubes or conduits communicating between said air compressor and said outlet ports, gate valves arranged in said conveying tubes or conduits adjacent to said outlet ports, a valve cylinder arranged in combination with said gate valves, tubular conduit connections between said valve cylinder and said air compressor, and means for operating said valve cylinder and gate valves by compressed air. Eight claims.

926,252. SHEET-METAL BOAT. GEORGE H. HYDE, OF WATERTOWN, N. Y.

Claim.—In a sheet-metal boat duplicate sets of sheet-metal plates forming the sides and bottom of the boat, those of each set being dis-

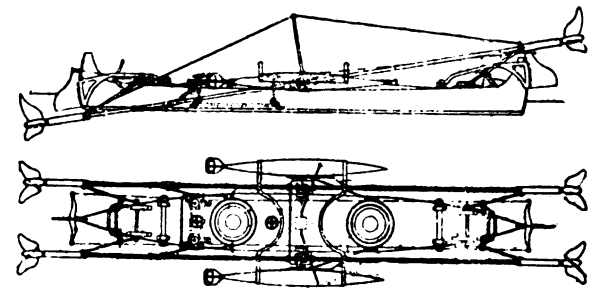


posed one above the other, the upper section gradually diminishing in width from its ends toward the center, and a lower section gradually increasing in width from its ends toward the center, the adjacent lengthwise edges of the plates of each set being of substantially the same length. One claim.

British patents compiled by Edwards & Co., chartered patent agents and engineers, Chancery Lane Station Chambers, London, W. C.

25,108. TORPEDO BOATS. R. MINIUSSI AND J. G. BLANCH, BUENOS AIRES, ARGENTINA.

A torpedo boat is fitted with two propeller shafts having propellers at both ends and so mounted that the rear or the forward propellers may be submerged at will for running forward or astern. The shafts are carried in bearing-bosses freely mounted at the ends of the cross-shaft coupled to the engine, and are stiffened by folding struts and tie-rods. The tilting of the shafts is effected by an operator in a turntable by means of hand wheels acting through worm-gearing to rotate the cranks



connected to loose sleeves on the shafts. The rudders are raised and lowered by the shafts, but so as to leave the water later and enter it earlier than the corresponding propellers. The steering is controlled by the operator through hand wheels, worm-gearing, and chains. The torpedos are carried in clamps mounted on frames, which are freely mounted on the outside of the bosses and are connected across the boat by arms. The launching is effected by a second operator seated in another turntable by means of a pivoted lever provided for each torpedo. The successive movement of the lever acts, first through a link to incline the frame and start the motor of the torpedo by a starting device thereon coming against a fixed lug, and next through a link which acts on arms to open the parts of the clamps. The torpedo then enters the water, and a further movement of the link causes a rack to engage a wheel and open a valve for admitting compressed air into a collapsed chamber normally held between the torpedo and the clamps, so as to maintain the stability of the boat. The turntables are mounted on roller bearings, and are provided with a cover of waterproof fabric fitting round the operator's waist. To prevent water from entering the boat around the turntable, an annular ring of rubber is secured at its inner edge to the turntable, and is provided at its outside edge with a beading which is secured by a spring ring clamp. The clamp ring may be raised sufficiently to allow the turntable to rotate without the beading escaping.

25,904. MAGNETIC COMPASSES. G. P. ASHBURNER, AND G. F. HARVEY, LIVERPOOL.

Relates to electric means for indicating when a ship leaves her set course. A contact on the compass card is set to lie between two contacts carried by the inner and outer parts, respectively, on the inner gimbal ring, these parts being insulated from one another. The outer gimbal ring is in two halves insulated from one another and the current flows through the pivots when the card swings in one direction or the other. A contact dipping into a mercury cup on the card completes circuit in each case.

26,441. CLEANING SHIPS' HULLS. SHIP CLEANING COMPANY, AND W. R. MACDONALD, LONDON.

A number of flexibly-connected battens carry wire mats constituting a cleaning device for ships' hulls. The battens are held against the hull electro-magnetically. Solid plates are provided having their faces more sharply curved than the slope of the wire bristles. The magnets are situated in recesses in the battens, which are only partly closed by plates; cooling water is therefore able to circulate around the windings, which are insulated by rubber or other suitable material. The parallel battens are connected by chains and may be further divided along their length to enable the mat to conform more readily to the contour of the hull. In order that the mat may be easily placed in position, it is maintained in a vertical position in the water by a number of corks attached to the upper edge, or by lead attached to the lower edge.

27,715. COMPARTMENTS; CARGO BOARDS. R. MACGREGOR, HOBOKEN, LEZ ANVERS, BELGIUM.

A vessel of ordinary exterior construction is provided with inner longitudinal bulkheads, extending upwardly and inwardly from a watertight flat, situated at or about the upper turn of the bilge, to the deck. By this construction, a main cargo space is formed in which central shifting boards are not necessary, and also side spaces, which may be utilized for cargo or water-ballast. A watertight flat is fitted in the side spaces at some distance above the bilge. The tonnage space of the hold may be varied by arranging inclined removable boards supported on bearers, sloping from the floor of the hold towards the bulkheads.

27,810. SHIPS. N. ILIINE, ST. PETERSBURG, RUSSIA.

In a pumping system for emptying ships' holds, the pumps in the various holds or compartments are coupled to water wheels or turbines, which are driven by high-pressure water from a main. The high-pressure service may also be utilized for fire-extinguishing purposes.

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